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RE: Application Serial No.: 10/660,635
Applicants: Takumi AKATSUKA, et al.
Filing Date: September 12, 2003
For: METHOD AND APPARATUS FOR MEASURING SHAPE OF TUBULAR BODY
Group Art Unit: 2856
Examiner: BENNETTE, G.

SIR:

Attached hereto for filing are the following papers:

Submission of Certified English Translation
Certification of Translation (3)
Certified English Translation (3)

Our check in the amount of **$0.00** is attached covering any required fees. In the event any variance exists between the amount enclosed and the Patent Office charges for filing the above-noted documents, including any fees required under 37 C.F.R 1.136 for any necessary Extension of Time to make the filing of the attached documents timely, please charge or credit the difference to our Deposit Account No. 15-0030. Further, if these papers are not considered timely filed, then a petition is hereby made under 37 C.F.R. 1.136 for the necessary extension of time. A duplicate copy of this sheet is enclosed.

Respectfully submitted,

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DOCKET NO: 242829US90

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF	:
TAKUMI AKATSUKA, ET AL.	: EXAMINER: BENNETT, G.
SERIAL NO: 10/660,635	:
FILED: SEPTEMBER 12, 2003	: GROUP ART UNIT: 2856
FOR: METHOD AND APPARATUS FOR MEASURING SHAPE OF TUBULAR BODY	:

SUBMISSION OF CERTIFIED ENGLISH TRANSLATION

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

SIR:

Applicants submit herewith certified English translations of the application Nos. 60/413,439, 60/421,079 and 60/447,745, as filed, in the above-identified application.

Respectfully submitted,

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DECLARATION

I, YOshihoto Shimizu, residing at Shimizu Patent Attorneys Office of 7F Idemitsu-Nagahori Bldg., 4-26, Minamisemba 3-chome, Chuoku, Osaka, JAPAN, do hereby certify that I am conversant with the English and Japanese languages and am a competent translator thereof. I further certify that to the best of my knowledge and belief the attached English translation is a true and correct translation made by me of U.S. Provisional Patent Application No. 60/413,439 filed September 26, 2002.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 7th day of February, 2005

Yoshihito Shimizu

Yoshihito Shimizu

[Name of Document] Specification

[Title Of Invention] METHOD FOR MEASURING A SHAPE OF A TUBULAR MEMBER, APPARATUS FOR MEASURING THE SAME, METHOD FOR INSPECTING A TUBULAR MEMBER, APPARATUS FOR INSPECTING THE SAME, METHOD FOR MANUFACTURING A TUBULAR MEMBER, AND SYSTEM FOR MANUFACTURING THE SAME.

[Detail Explanation of the Invention]

[0001]

[Field of Invention]

The present invention relates to a method for measuring a shape of a tubular member, such as a substrate of a photosensitive drum for use in copying machines, an apparatus for measuring the same, a method for inspecting a tubular member, a system for inspecting the same, a method for manufacturing a tubular member, and a system for manufacturing the same.

[0002]

[Background Art]

In a tubular body to be used as a rotating member or the like in various machines, it is sometimes required to measure the precision of the shape. For example, in a substrate of a photosensitive drum for use in electrophotographic systems such as copying machines, a tubular body after the tube manufacturing steps is subjected to a shape measuring to keep high precision of the shape.

[0003]

As a method for measuring the shape, there is a method shown in Figs. 23 and 24. In this method, in a state in which the external peripheral surface 12 of portions near both ends of the tubular body 10 are supported by reference rollers 91, displacement measuring

devices 92 are brought into contact with three positions on the longitudinal central portion of the external peripheral surface of the tubular body 10. Then, the tubular body 10 is rotated by rotating the reference rollers 91 to obtain the variation of the detected values of the displacement measuring devices 92. Using the detected values, the displacement at the longitudinal central portions of the external peripheral surface of the tubular body 90 is measured. Such obtained displacement reflects the deflection of the central external peripheral surface with respect to the external peripheral surfaces of the longitudinal end portions of the tubular body 10.

[0004]

In cases where the tubular body 90 is rotatably supported at the inner peripheral surfaces of the end portions, the thickness distribution (unevenness of thickness) of the tubular body 90 affects the accuracy of rotation. Accordingly, in cases where high precision of shape is required, it can be considered that it is evaluated taking account of the degree of unevenness of thickness by measuring the maximum thickness and the minimum thickness of the tubular body 90.

[0005]

Various techniques for measuring a shape of a tubular body are disclosed by, for example, Japanese Unexamined Laid-open Publication Nos. H11-271008, S63-131018, 2001-3369920, H08-141643, H11-63955, H03-113114, 2000-292161 and H02-275305.

[0006]

[Patent Document 1] Japanese Unexamined Laid-open Publication Nos. H11-271008

[0007]

[Patent Document 2] Japanese Unexamined Laid-open Publication No. S63-131018

[0008]

[Patent Document 3] Japanese Unexamined Laid-open Publication No. 2001-3369920

[0009]

[Patent Document 4] Japanese Unexamined Laid-open Publication No. H08-141643

[0010]

[Patent Document 5] Japanese Unexamined Laid-open Publication No. H11-63955

[0011]

[Patent Document 6] Japanese Unexamined Laid-open Publication No. H03-113114

[0012]

[Patent Document 7] Japanese Unexamined Laid-open Publication No. 2000-292161

[0013]

[Patent Document 8] Japanese Unexamined Laid-open Publication No. H02-275305.

[0014]

[PROBLEMS TO BE SOLVED BY THE INVENTON]

However, the method for measuring the shape of the tubular body using the deflection measurement of the external peripheral surface of the tubular body 90 shown in Figs. 23 and 24 and the thickness measurement using thickness measuring devices has the following problems.

[0015]

(1) Since the deflection measurement of the external peripheral surface and the thickness measurement are performed by using different measuring devices, device differences among the measuring devices, errors arose from the handling of measuring devices and dispersion of the measuring persons will accumulate, which makes it difficult to attain high accuracy of measurement.

[0016]

(2) Although the deflection of the external peripheral surface and the distribution of the thickness may sometimes be set off geometrically, both of them are measured separately. Therefore, the aforementioned circumstances cannot be considered. As a result, there is a possibility that excessive quality is requested.

[0017]

Furthermore, the aforementioned publications fail to disclose techniques capable of measuring deflection of an external peripheral surface of a tubular body easily with high precision.

[0018]

Furthermore, it can be considered to employ a method for measuring a shape of a tubular body using a conventional circularity measuring device. In this case, however, it is required to repeatedly perform every tubular element such that the rotating axis of a measurement table on which the tubular body is disposed and the central axial position of the tubular body to be measured are aligned and that the rotating axis of the measurement table and the central axis of the tubular body are aligned in parallel, which takes a lot of time and trouble.

[0019]

In view of the above-identified problems, the present invention aims to provide a method for measuring a shape of a tubular member capable of measuring the shape with a high degree of accuracy, an apparatus for measuring the same, a method for inspecting such a tubular member, a system for inspecting the same, a method for manufacturing such a tubular member, and a system for manufacturing the same.

[0020]

[MEANS FOR SOLVING THE PROBLEMS]

The present invention provides the following means. That is:

(1) A method for measuring a shape of a tubular body, comprises:

making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body at at least one position outside the tubular element, the at least one position being fixed relative to the circumferential direction of the tubular element.

[0021]

(2) The method for measuring a shape of a tubular body as

recited in the aforementioned Item 1, the pair of reference portions are brought into contact with supporting positions in the actual use of the tubular body.

[0022]

(3) The method for measuring a shape of a tubular body as recited in the aforementioned Item 1 or 2, wherein the pair of reference portions are brought into approximately point-contact with the internal peripheral surface of the tubular body respectively.

[0023]

(4) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 3, wherein the pair of reference portions is arranged in a horizontal direction.

[0024]

(5) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 3, wherein the pair of reference portions is arranged in a vertical direction.

[0025]

(6) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 5, wherein detecting positions of the displacement include at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body.

[0026]

(7) A method for measuring a shape of a tubular body, comprises:

making a pair of reference portions come into contact with

internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of the external peripheral surface of the tubular body at at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body.

[0027]

(8) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 7, wherein the detecting positions of the displacement include a position other than a position facing off against the pair of reference portions from an outside of the tubular body.

[0028]

(9) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 8, wherein the detecting positions of the displacement include plural positions located outside the tubular body.

[0029]

(10) The method for measuring a shape of a tubular body as recited in the aforementioned Item 9, wherein the detecting positions of the displacement include plural positions different in the axial

direction of the tubular body.

[0030]

(11) The method for measuring a shape of a tubular body as recited in the aforementioned Item 9 or 10, wherein the detecting positions of the displacement include plural positions which are the same in axial directional position of the tubular body but different in peripheral directional position thereof.

[0031]

(12) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 9 to 11, wherein the detecting positions of the displacement include two positions which are the same in axial directional position of the tubular body but different in peripheral directional position by a half peripheral length of the tubular body.

[0032]

(13) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 9 to 12, wherein the detecting positions of the displacement include a position outside the tubular body facing off against at least one of the pair of reference portions.

[0033]

(14) A method for measuring a shape of a tubular body, comprises:

making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a

circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of the external peripheral surface of the tubular body at a position outside the tubular body facing off against at least one of the pair of reference portions and at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body.

[0034]

(15) A method for measuring a shape of a tubular body, comprises:

making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of the external peripheral surface of the tubular body at a position outside the tubular body facing off against at least one of the pair of reference portions, a position different from the position in peripheral directional position by a half peripheral length of the tubular body, and at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from

an outside of the tubular body.

[0035]

(16) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 5, wherein the number of the rotation of the tubular body is one or more.

[0036]

(17) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 16, wherein the detection of the displacement is performed continuously during the entire period or a part of the period for rotating the tubular body.

[0037]

(18) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 16, wherein the detection of the displacement is performed intermittently during the period for rotating the tubular body.

[0038]

(19) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 16, wherein the rotation of the tubular body is intermittently stopped and the detection of the displacement is performed when the rotation of the tubular body is stopped.

[0039]

(20) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 19, wherein the detection of the displacement is performed by using a detecting device which comes into contact with the external peripheral surface of the tubular body.

[0040]

(21) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 19, wherein the detection of the displacement is performed by using a detecting device which does not come into contact with the external peripheral surface of the tubular body.

[0041]

(22) The method for measuring a shape of a tubular body as recited in the aforementioned Item 21, wherein the detection of the displacement is performed by irradiating light against the tubular body from the outside thereof and detecting the light passed over the tubular body.

[0042]

(23) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 22, wherein the tubular body is a photosensitive dram substrate.

[0043]

(24) A method for inspecting a tubular body, comprising: measuring a shape of the tubular body in accordance with the method of measuring a tubular body as recited in any one of the aforementioned Items 1 to 23; and inspecting based on the measured result whether the shape of the tubular body falls within a predetermined allowable range.

[0044]

(25) A method for manufacturing a tubular body, comprising:

manufacturing a tubular body;

inspecting a shape of the tubular body by the inspection method

of a tubular body as recited in the aforementioned Item 24; and

discriminating that the tubular body is a completed product if the inspection result shows that the shape of the tubular body falls within the predetermined allowable range.

[0045]

(26) An apparatus for measuring a shape of a tubular body, comprising: a pair of expandable clamps to be brought into contact with an internal peripheral surface of the tubular body at both end portions of the tubular body; and at least one displacement detecting device provided outside the tubular body for detecting a radial displacement of the external peripheral surface of the tubular body, wherein the displacement detecting device detects the displacement in accordance with the rotation of the tubular body when the tubular body is rotated together with the reference portion about a rotational axis around the central axis of the pair of reference portions.

[0046]

(27) An apparatus for inspecting a shape of a tubular body, comprising: the apparatus for measuring a shape of a tubular body as recited in the Item 26; and a comparative means for inspecting whether the shape of the tubular body falls within a predetermined allowable range based on the displacement detected by the displacement detecting device.

[0047]

(28) A system for manufacturing a tubular body, comprising:

a tube manufacturing apparatus for manufacturing a tubular body;

an inspection apparatus for a tubular body as recited in the

aforementioned Item 27;

an acceptance/rejection discriminating means for discriminating that the tubular body is a completed product if the inspection result by the inspection apparatus shows that the shape of the tubular body falls within the predetermined allowable range.

[0048]

A method for measuring a shape of a tubular body according to the present invention comprises:

making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body at at least one position outside the tubular element, the at least one position being fixed relative to the circumferential direction of the tubular element.

[0051]

Furthermore, since the deflection of the external peripheral surface to be measured reflects the influence of uneven thickness, it is possible to prevent the accumulation of device differences and/or a request of excessive quality which may occur in the case of separately measuring the thickness of the tubular body.

[0052]

Furthermore, since the deflection of the external peripheral surface to be measured reflects the influence of uneven thickness, the time required to conduct the measurement can be shortened.

[0053]

Furthermore, since the external peripheral surface is measured by bringing the reference portion into contact with the internal peripheral surface, the structure can be simplified, decreasing the accumulation of measuring errors as small as possible, resulting in a high accuracy shape measuring.

[0054]

Furthermore, since it is enough to bring the reference portion into contact with the internal peripheral surface, this method can be preferably applied to a method of measuring a shape of a tubular body having a smaller diameter.

[0055]

It is enough that the position of the reference portion is fixed when the tubular body is rotated to detect the displacement of the external peripheral surface of the tubular body. For example, the position can be moved when the tubular body is set to an apparatus for measuring the shape. Furthermore, it is enough that the position of the reference portion is fixed. The posture can be changed, e.g., rotated.

[0056]

In such a measuring method, it is preferable that the pair of reference portions is brought into contact with supporting positions at the time of using the tubular body.

[0057]

In this case, since the shape measurement can be performed by making the reference portion for rotation operations at the actual use of the tubular body as a reference, it becomes possible to perform measurement in a situation near the actual case.

[0058]

It is preferable that the pair of reference portions are brought into approximately point-contact with the internal peripheral surface of the tubular body respectively.

[0059]

In this case, it becomes possible to perform a shape measurement clearly specifying the measurement reference.

[0060]

The pair of reference portions can be arranged in a horizontal direction.

[0061]

In this case, the tubular body takes a posture with the axial direction approximately horizontal. However, in cases where the tubular body is used in this posture, it becomes possible to obtain measured results similar to those in the use.

[0062]

The pair of reference portions can be arranged in a vertical direction.

[0063]

In this case, the deflection of the axially central portion of the tubular body due to its gravity can be prevented, which makes it possible to measure its original shape.

[0064]

It is preferable that detecting positions of the displacement include at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body.

[0065]

The position facing off against the hypothetic straight line from outside the tubular body is a position where radial displacement of the external peripheral surface of the tubular body barely receives the influence of the shift of the rotational central position of the tubular body. Therefore, if the position includes such position, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement.

[0066]

A method for measuring a shape of a tubular body according to the present invention comprises:

making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of the external peripheral

surface of the tubular body at at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body.

[0067]

With this method for measuring a shape of a tubular body, deflection of the external peripheral surface with respect to the internal peripheral surface can be measured. That is, the deflection of the external peripheral surface to be measured reflects the influence of the uneven thickness of the tubular body. The position facing off against the hypothetic straight line from outside the tubular body is a position where radial displacement of the external peripheral surface of the tubular body barely receives the influence of the shift of the rotational central position of the tubular body. Therefore, if the position includes such position, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement.

[0068]

It is preferable that the detecting positions of the displacement include a position other than a position facing off against the pair of reference portions from an outside of the tubular body.

[0069]

In this case, deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body can be measured.

[0070]

It is preferable that the detecting positions of the displacement include plural positions located outside the tubular body.

[0071]

In this case, the deflection of the external peripheral surface at the plural positions located outside the tubular body can be measured, and therefore, by combining these it becomes possible to grasp the shape of the tubular body more concretely.

[0072]

Furthermore, it is preferable that the detecting positions of the displacement include plural positions different in the axial direction of the tubular body.

[0073]

In this case, the deflection of the external peripheral surface at the plural positions different in the axial direction of the tubular body can be measured, and therefore, by combining these it becomes possible to grasp the shape of the tubular body more concretely.

[0074]

Furthermore, it is preferable that the detecting positions of the displacement include plural positions which are the same in axial directional position of the tubular body but different in peripheral directional position thereof.

[0075]

In this case, by combining the displacements detected at a plurality of positions, it is possible to grasp the cross-sectional shape of the tubular body at the axial position more concretely.

[0076

Furthermore, it is preferable that the detecting positions of the displacement include two positions which are the same in axial directional position of the tubular body but different in peripheral directional position by a half peripheral length of the tubular body.

[0077]

In this case, by combining the displacements detected at two positions, it is possible to obtain the diameter of the tubular body passing two positions. Thus, the cross-sectional shape of the tubular body at the axial position more concretely.

[0078]

Furthermore, it is preferable that the detecting positions of the displacement include a position outside the tubular body facing off against at least one of the pair of reference portions.

[0079]

In this case, it is possible to detect the thickness of the tubular body at the portion where the reference portion is in contact with. By combining this thickness with the detected results at another detecting positions, the cross-sectional shape of the tubular body at the axial position more concretely. For example, it is also possible to calculate inspected results in accordance with a conventional inspection method in which displacement of the external peripheral surface of another position with respect to the external peripheral surface of the vicinity of the end portion of the tubular body as a reference is measured.

[0080]

A method for measuring a shape of a tubular body according to the present invention comprises:

making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of the external peripheral surface of the tubular body at a position outside the tubular body facing off against at least one of the pair of reference portions and at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body.

[0081]

With this method for measuring a shape of a tubular body, it is possible to detect the thickness of the tubular body at the portion where the reference portion is in contact with from the displacement of the external peripheral surface at the position facing off against the reference portion. Furthermore, from the displacement of the external peripheral surface at the position facing off against a hypothetical linear line, deflection of the external peripheral surface with reference to the interior peripheral surface of the tubular body, i.e., deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body, can be measured. Especially, the position facing off against the

hypothetical linear line from the outside of the tubular body is a position where the radial displacement of the external peripheral surface is barely affected by the influence of the shift of the rotational center of the tubular body. Therefore, by taking such a position as a detecting position of the displacement, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement. By combining the detected thickness of the tubular body and the deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body, t becomes possible to grasp the shape of the tubular body more concretely. For example, it is also possible to calculate inspected results in accordance with a conventional inspection method in which displacement of the external peripheral surface of another position with respect to the external peripheral surface of the vicinity of the end portion of the tubular body as a reference is measured.

[0082]

A method for measuring a shape of a tubular body according to the present invention comprises:

making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body;

rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and

detecting radial displacement of the external peripheral surface of the tubular body at a position outside the tubular body facing off against at least one of the pair of reference portions, a position different from the position in peripheral directional position by a half peripheral length of the tubular body, and at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body.

[0083]

With this method for measuring a shape of a tubular body, it is possible to detect the thickness of the tubular body at the portion where the reference portion is in contact with from the displacement of the external peripheral surface at the position facing off against the reference portion. Furthermore, from the displacement of the external peripheral surface at the position facing off against a hypothetical linear line and the deflection of the external peripheral surface facing off against the reference portion, the diameter passing through these two positions can be can be measured. Furthermore, from the displacement of the external peripheral surface at the position facing off against a hypothetical linear line, the deflection of the external peripheral surface with reference to the interior peripheral surface of the tubular body, i.e., the deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body can be measured. Especially, the position facing off against the hypothetical linear line from the outside of the tubular body is a position where the radial

displacement of the external peripheral surface is barely affected by the influence of the shift of the rotational center of the tubular body. Therefore, by taking such a position as a detecting position of the displacement, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement. By combining the detected thickness of the tubular body and the deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body, t becomes possible to grasp the shape of the tubular body more concretely. For example, it is also possible to calculate inspected results in accordance with a conventional inspection method in which displacement of the external peripheral surface of another position with respect to the external peripheral surface of the vicinity of the end portion of the tubular body as a reference is measured.

[0084]

Furthermore, it is preferable that the number of the rotation of the tubular body is one or more.

[0085]

In this case, it is possible to detect the shape along the entire periphery of the tubular body.

[0086]

The detection of the displacement can be performed continuously during the entire period or a part of the period for rotating the tubular body.

[0087]

In this case, it is also possible to detect a partial shape change

in the peripheral direction of the tubular body.

[0088]

The detection of the displacement can be performed intermittently during the period for rotating the tubular body.

[0089]

In this case, it is possible to easily detect the displacement of the external peripheral surface of the tubular body.

[0090]

The rotation of the tubular body can be intermittently stopped and the detection of the displacement is performed when the rotation of the tubular body is stopped.

[0091]

In this case, it is possible to stably detect the displacement of the external peripheral surface of the tubular body.

[0092]

The detection of the displacement can be performed by using a detecting device which comes into contact with the external peripheral surface of the tubular body.

[0093]

In this case, it is possible to assuredly detect the displacement of the external peripheral surface of the tubular body.

[0094]

The detection of the displacement can be performed by using a detecting device which does not come into contact with the external peripheral surface of the tubular body.

[0095]

In this case, it is possible to detect the displacement of the

external peripheral surface of the tubular body without harming the external peripheral surface of the tubular body.

[0096]

the detection of the displacement can be performed by irradiating light against the tubular body from the outside thereof and detecting the light passed over the tubular body.

[0097]

In this case, it is possible to easily and accurately detect the displacement of the external peripheral surface of the tubular body.

[0098]

Furthermore, as the tubular body preferably applied to the method for measuring a shape of a tubular body according to the present invention, a photosensitive dram substrate can be exemplified.

[0099]

A method for inspecting a tubular body according to the present invention comprise the steps of measuring a shape of the tubular body in accordance with the method of measuring a tubular body as recited in any one of the aforementioned Items, and inspecting based on the measured result whether the shape of the tubular body falls within a predetermined allowable range.

[0100]

With the method for inspecting a tubular body, it is possible to discriminate whether the shape of the tubular body falls within a predetermined allowable range.

[0101]

A method for manufacturing a tubular body according to the

present invention comprises the steps of manufacturing a tubular body, inspecting a shape of the tubular body by the inspection method of a tubular body as recited in the aforementioned Item; and discriminating that the tubular body is a completed product if the inspection result shows that the shape of the tubular body falls within the predetermined allowable range.

[0102]

With this method for manufacturing a tubular body, it is possible to provide a tubular body having sufficient shape accuracy without excessively increasing the quality.

[0103]

An apparatus for measuring a shape of a tubular body according to the present invention comprises: a pair of expandable clamps to be brought into contact with an internal peripheral surface of the tubular body at both end portions of the tubular body; and at least one displacement detecting device provided outside the tubular body for detecting a radial displacement of the external peripheral surface of the tubular body, wherein the displacement detecting device detects the displacement in accordance with the rotation of the tubular body when the tubular body is rotated together with the reference portion about a rotational axis around the central axis of the pair of reference portions.

[0104]

With this method for measuring a shape of a tubular body, it is possible to measure the deflection of the external peripheral surface of the tubular body. That is, the deflection of the external peripheral surface reflects the influence of the uneven thickness

of the tubular body in cases where the interior peripheral surface of the tubular body to be measured is supported. Therefore, it is possible to conduct a measurement similar to the using state of the tubular body. Furthermore, since the deflection of the external peripheral surface reflects the influence of the uneven thickness of the tubular body, it is possible to prevent accumulation of variation of measuring devices and an excessive quality request which are required when a thickness of the tubular body is measured separately. Furthermore, since the deflection of the external peripheral surface reflects the influence of the uneven thickness of the tubular body, it is possible to shorten the measuring time. Furthermore, since the measurement of the external peripheral surface is performed simply by bringing the reference portion into contact with the interior peripheral surface, the structure can be simplified, reducing the accumulation of the measuring errors as low as possible, which in turn can obtain high accuracy of shape measurement. Furthermore, since it is enough to bring the reference portion into contact with the internal peripheral surface, this method can be preferably applied to a method of measuring a shape of a tubular body having a smaller diameter.

[0105]

An apparatus for inspecting a shape of a tubular body according to the present invention comprise the apparatus for measuring a shape of a tubular body as recited in the Item, and a comparative means for inspecting whether the shape of the tubular body falls within a predetermined allowable range based on the displacement detected by the displacement detecting device.

[0106]

With the apparatus for inspecting a tubular body, it is possible to discriminate whether the shape of the tubular body falls within a predetermined allowable range.

[0107]

A system for manufacturing a tubular body according to the present invention comprises a tube manufacturing apparatus for manufacturing a tubular body, an inspection apparatus for a tubular body as recited in the aforementioned Item, an acceptance/rejection discriminating means for discriminating that the tubular body is a completed product if the inspection result by the inspection apparatus shows that the shape of the tubular body falls within the predetermined allowable range.

[0108]

With the system for manufacturing a tubular body, it is possible to provide a tubular body having sufficient shape accuracy without causing excessive quality.

[0109]

[EMBODIMENTS OF THE INVENTION]

(PRINCIPAL OF MEASUREMENT)

Although various embodiments of a method and an apparatus for measuring a shape of a tubular body according to the present invention will be explained as follows, first, the principal of the measurement will be explained with reference to schematic drawings.

[0110]

Fig. 1 is a front cross-sectional view showing the principle of a method for measuring a shape of a tubular body according to the

present invention. Fig. 2 is a side cross-sectional view threreof. Fig. 3 is a perspective view thereof. Fig. 4 is an explanatory perspective view showing the use status of the tubular body (work) as a shape measuring object. Fig. 5 is an explanatory view of a detecting position for displacement in a method for measuring a shape of a tubular body according to the present invention.

[0111]

<Tubular body>

In the present invention, it is assumed that a tubular body to be measured is a cylindrical member having an internal peripheral surface and an external peripheral surface which are circular in cross-section. Furthermore, the tubular body (work) 10 exemplified in this embodiment is a member which will be used while being rotated in a state in which the opposite ends are supported by flanges 80 and 80 inserted therein as shown in Fig. 4. The positions where these flanges 80 and 80 are brought into contact with the tubular body 10 so as to rotatably support it are, for example, the areas S (areas with hatching lines in Fig. 4) with a width d from both ends of the tubular body 10.

[0112]

As the material of such a tubular body (work) 10, aluminum alloy can be exemplified. However, it is not limited to this and can be various metals or synthetic resins.

[0113]

As the manufacturing method, a combination of extrusion molding and drawing molding can be exemplified as will be described later. However, it is not limited to this and can be any method capable of

manufacturing a tubular body, such as extrusion molding, drawing molding, casting, forging, injection molding, cutting or a combination thereof.

[0114]

As such a tubular body 10, in concrete, a photosensitive rum substrate or raw tube for use in copying machines or printers employing an electrophotography system can be exemplified.

[0115]

<Outline>

As shown in Figs. 1 to 3, in the method for measuring a shape of a tubular body according to the present invention, a pair of reference portions 20 and 20 are brought into contact with the internal peripheral surface 11 of the tubular body (work) 10 at the vicinities of both end portions, and the radial displacement of the external peripheral surface 12 of the tubular body 10 is detected by each of displacement detecting devices 30 arranged outside the tubular body 10 while rotating the tubular body 10.

[0116]

The rotation of the tubular body 10 can be performed by grasping the tubular body 10 with an operator's hand, bringing a driving roller (not shown) into contact with the tubular body 10 or using any other method. The rotational center of the tubular body 10 is located approximately at a position corresponding to the axial center of the tube shape of the tubular body 10.

[0117]

<Reference portion>

The positions of the pair of reference portions 20 and 20 are

fixed at least when the tubular body 10 is rotated, and thus the contact portions relative to the tubular body 10 advance on the internal peripheral surface 11 of the tubular body 10 in the circumferential direction. This tubular body 10 is positioned by the pair of reference portions 20 and 20 at least when the tubular body is rotated to define the reference of the shape measurement.

[0118]

In this illustration, the pair of reference portions 20 and 20 are in contact with the tubular body 10 at positions (within the regions S with hatching lines in Fig. 4) to be supported at the time of the actual use of the tubular body 10. By this, the portions which will be the rotational operation references at the time of the actual use of the tubular body 10 can be references for the shape measurement, which realizes more practical measurement.

[0119]

Furthermore, the pair of reference portions 20 and 20 are formed into a spherical shape, respectively, and in contact with the internal peripheral surface 11 of the tubular body 10 approximately in a point contact state, respectively. This enables a clear specification of the reference position for the shape measurement.

[0120]

<Displacement detecting device>

The displacement detecting devices 30 are arranged outside the tubular body 10, and their circumference direction positions of the tubular body 10 (displacement detecting positions 31…, 32…) are fixed at least when the tubular body 10 is rotated. In other words, in accordance with the rotation of the tubular body 10, the displacement

detecting positions 31 and 32 by the displacement detecting devices 30 advance on the external peripheral surface 12 of the tubular body 10 in the circumferential direction thereof.

[0121]

The radial displacement of the external peripheral surface 12 of the tubular body 10 to be detected by the displacement detecting devices 30 means the so-called deflection (external diameter deflection). In this invention, one of features resides in that the deflection of the external peripheral surface 12 with respect to the internal peripheral surface 11 of the tubular body 10 is detected (measured) by the aforementioned pair of reference portions 20 and 20 in contact with the internal peripheral surface 11 of the tubular body 10.

[0122]

In this illustrations, one embodiment in which five displacement detecting devices 30 are arranged so that five positions different in the axial directional position of the tubular body 10 can be displacement detecting positions 31 and 32 is exemplified.

[0123]

Especially, two outermost displacement detecting devices 30 and 30 are disposed at the positions 31 and 31 facing off against the pair of reference portions 20 and 20 at the vicinities of both ends of the tubular body 10 as displacement detecting positions 31 and 31. At these positions 31 and 31, the thickness of the tubular body 10 pinched by and between the reference portion 20 and the displacement detecting device 30 can be measured.

[0124]

On the other hand, the other three displacement detecting devices 30 are disposed at positions 32 other than the positions 31 and 31 corresponding to the pair of reference portions 20 and 20 as displacement detecting positions. At each of these positions 32, the deflection of the external peripheral surface of the tubular body 10 can be detected.

[0125]

The circumferential positions of the five displacement detecting devices 30 are positions 31 and 32 corresponding to a hypothetical straight line Q passing two contact points P1 and P2 where the internal peripheral surface 11 of the tubular body 10 and the pair of reference portions 20 and 20 contact via a thickness (region R with hatching lines shown in Fig. 3) of the tubular body 10 from the outside of the tubular body 10, as shown in Fig. 3.

[0126]

Fig. 5 is an explanatory drawing for explaining the features of each displacement detecting position with respect to the circumferential direction of the tubular body 10.

[0127]

In the method for measuring a shape of a tubular body according to the present invention, the position of each reference portion 20 is fixed stably since the reference portion 20 is a benchmark of the shape measurement. However, there is a possibility that the tubular body 10 contacting the reference portion 20 is unstable in position (posture of the tubular body 10) except for the positions contacting the reference portions 20. For example, as shown in Fig. 5, there is a possibility that the tubular body 10 which is being measured

(rotated) shifts from the state shown by the actual line with the center located at the position O to the state shown by the phantom line with the center located at the position O'.

[0128]

At this time, the position A facing off against the hypothetical straight line Q passing the contact portions P1 and P2 in contact with the reference portion 20 is a position where the shift (O→O') of the tubular body least affects the displacement of the external peripheral surface 12 of the tubular body 10 in the radial direction (in the direction of the arrow shown at each position A, B, C, D in Fig.5). In other words, once the positions facing off against the hypothetical straight line Q are set to be displacement detecting positions, even if the tubular body 10 shifts during the measurement, the measured displacements hardly receive the influence, resulting in stable measurement.

[0129]

In a concrete apparatus for measuring a shape which will be described later, it is configured so as to stabilize the position of the tubular body 10 to decrease the problem that the tubular body 10 shifts during the measurement.

[0130]

When the tubular body 10 is rotated in a state in which the pair of reference portions 20 and 20 are in contact with the internal peripheral surface 11 of the tubular body 10, there will be no radial displacement of the external peripheral surface 12 if the tubular body 10 is perfectly circular in cross-sectional shape. To the contrary, if the tubular body 10 is not perfectly circular, the

deviation will be detected as the displacement of the external peripheral surface by the displacement detecting devices 30.

[0131]

(Examples of defective tubes)

Next, examples of typical defections of the tubular body 10 will be explained with reference to Figs. 6 to 8.

[0132]

<Bent tube>

Fig. 6(a) is a perspective view of a bent tube 101 as a defective example of the tubular body. The bent tube 101 denotes a tube whose axis is bent. Here, in order to exclude another defective factors, it is assumed that the circle formed by the internal peripheral surface (internal peripheral circle) and the circle formed by the exterior peripheral surface (exterior peripheral circle) in each cross-section are perfectly circular along the entire length, and that the center of the internal peripheral circle and that of the external peripheral circle coincide with each other (concentric), and therefore the thickness of the tubular body is uniform.

[0133]

In the actual use of such a bent tube 101, as explained with reference to Fig. 4, when the tube 101 is rotated by the flanges inserted into both ends of the tubular body, as shown in Fig. 6(a), the bent tube 101 rotates about the straight line T1 passing the centers of the internal peripheral circles at the vicinities of both ends of the tube 101, causing deflation at the axial central portion of the bent tube 101. The chain double-dashed line in Fig. 6(a) shows the state rotated by 180 degrees from the state shown by the solid

line.

[0134]

Fig. 6(b) is a cross-sectional view taken at the axial central portion of the bent tube 101, and the chain double-dashed line shows the external peripheral surface (external peripheral circle) in the state rotated by 180 degrees from the state shown by the solid line. As shown in this figure, although the tubular body 101 is pushed up in the state shown by the solid line, it is pushed down when rotated by 180 degrees as shown by the chain double-dashed line, and then it returns to the state shown by the solid line when further rotated by 180 degrees. That is, 360-degree-cycle deflection is generated.

[0135]

In the rotation using the flanges, the line passing the center of the internal peripheral circle at the vicinity of one end portion of the tubular body supported by the flange and the center of the internal peripheral circle at the vicinity of the other end portion of the tubular body supported by the flange constitutes the rotation axis T1. However, this rotation axis T1 and the center of the external peripheral circle are misaligned at the axial central portion of the bent tube 101. The deflection caused at the central portion in the axial direction of the bent tube 101 arises from the misalignment between the rotation axis T1 determined by the internal peripheral circles at the vicinities of both ends of the tube 101 and the center of the external peripheral circle in a cross-section to be observed.

[0136]

<Uneven thickness tube>

Fig. 7(a) is a perspective view of a tube 102 with uneven

thickness as a defective example of a tubular body (hereinafter referred to as "uneven thickness tube"). The uneven thickness tube denotes a tube in which the thickness differs in the circumferential direction at a cross-section of a tubular body. Here, in order to exclude another defective factors, it is assumed that the axis of the tubular body is a straight line, the circle formed by the internal peripheral surface (internal peripheral circle) and the circle formed by the exterior peripheral surface (exterior peripheral circle) are perfectly circular in each cross-section along the entire length thereof, but the center of the internal peripheral circle and that of the external peripheral circle are shifted (eccentric), and therefore the thickness is uneven. Furthermore, it is also assumed that the cross-sectional configuration is constant along the axial direction of the tubular body and that there is no twist.

[0137]

In the actual use of such an uneven thickness tube 102, as explained with reference to Fig. 4, when the tube is rotated by the flanges inserted into both ends of the tubular body, as shown in Fig. 7(a), the uneven thickness tube 102 rotates about the straight line T2 passing the centers of the internal peripheral circles at the vicinities of both ends of the tube 102, causing deflation at the entire length of the tube 102 along the axial direction. The chain double-dashed line in Fig. 7A shows the state rotated by 180 degrees from the state shown by the solid line.

[0138]

Fig. 7(b) is a cross-sectional view of the uneven thickness tube 102, and the chain double-dashed line shows the external peripheral

surface (external peripheral circle) in the sate rotated by 180 degrees from the state shown by the solid line. As shown in this figure, although the external peripheral surface of the tube 102 is raised upward as a whole since the thicker portion is located at the upper portion as shown by the solid line, the thicker portion is moved downward when it is rotated by 180 degrees as shown by the chain double-dashed line and the thinner portion is located at the upper position, and therefore the external peripheral surface is moved downward as a whole and then it returns to the state shown by the solid line. That is, 360-degree-cycle deflection is generated.

[0139]

In such a rotation by the flanges, in the same manner as the aforementioned bent tube, the line passing the center of the internal peripheral circle at the vicinity of one end portion of the tubular body supported by the flange and the center of the internal peripheral circle at the vicinity of the other end portion of the tubular body supported by the flange constitutes the rotation axis T2. In the uneven thickness tube 102, since the center of the internal peripheral circle and that of the external peripheral circle are misaligned along the entire length of the tube, the rotation axis T1 which is determined based on the internal peripheral surface and the center of the external peripheral circle are misaligned along the entire length of the bent 102. The deflection along the entire length of the uneven thickness tube 102 arises from the misalignment between the rotation axis T2 determined by the internal peripheral circles at the vicinities of both ends of the tube 102 and the center of the external peripheral circle at a cross-section to be observed.

[0140]

<Flat tube>

Fig. 8(a) is a perspective view of a tube 103 with a non-perfect circular cross-section as a defective example of a tubular body, especially a tube with a flat cross-section (hereinafter referred to as "flat tube"). The flat tube denotes a tube not having a perfect circular cross-section but having an elliptic cross-section formed by pressing from up-and-down direction or right-and-left direction. Here, in order to exclude another defective factors, it is assumed that the axis of the tubular body is a straight line, the cross-sectional shape of the internal peripheral circle and that of the exterior peripheral circle are almost similar, the thickness is almost constant, the cross-sectional shape is constant along the entire length with no twist.

[0141]

In the actual use of such a flat tube 103, as explained with reference to Fig. 4, it cannot be decided how the flanges are set with respect to the tubular body (flat tube), or how the position or the posture of the tubular body (flat tube) 103 is decided with respect to a rotation axis as a center of the flange because they are decided based on the relationship of the degree of flatness or the strength of the tubular body, the size of the flange and the strength of the flange. Here, it is assumed that both the flanges are set to both end portions of the tubular body 103 with the center of the flange aligned with the center of the internal peripheral circle of the flat tube. In this state, when the tubular body (flat tube) 103 is rotated, as shown in Fig.8(a), the flat tube rotates about

the straight line T3 passing the center of the internal peripheral circle as an axis, causing deflection along the entire axial length of the flat tube 103. The chain double-dashed line in Fig. 8(a) shows the state rotated by 90 degrees from the state shown by the solid line.

[0142]

Fig. 8(b) is a cross-sectional view of the flat tube 103, and the chain double-dashed line shows the external peripheral surface (external peripheral circle) in the state rotated by 90 degrees from the state shown by the solid line.

[0143]

As shown in this figure, although the tubular body 103 is taking a vertical posture in the state shown by the solid line, it will take a horizontal posture as shown by the chain double-dashed line when further rotated by 90 degrees, and then returns to the original posture shown by the solid line when further rotated by 90 degrees. As will be understood from the above, inward and outward displacements of the external peripheral surface will be repeated, causing 180-degree-cycle deflection.

[0144]

As mentioned above, it is assumed that the rotation axis T of this flat tube 103 passes the centers of the internal peripheral surfaces of both ends of the tubular body (flat tube) 103. Furthermore, in this example assuming that the cross-section is constant along the entire length of the tube, the rotational axis T passes the center of the external peripheral circle (not perfect circle) at any cross-section. Therefore, the deflection along the entire length of

the flat tube 103 arises from the fact that the external peripheral circle in each cross-section of the tubular body 103 is shifted from the perfect circle. Fig. 8(c) will be detailed later.

[0145]

(Measuring examples)

Next, the measurement of the shape of the aforementioned defective tube as an object to be measured will be explained with reference to Fig. 9. Fig. 9 shows graphs each showing the result of the displacement of the external peripheral surface of a tubular body (work) 10 as an object detected while rotating the tubular body 10. In Fig. 9, the horizontal axis denotes a rotation angle of the tubular body (work), and the vertical axis denotes the detected value of the radial displacement of the external peripheral surface of the tubular body 10 to be detected by the displacement detecting devices 30.

[0146]

<Measurement of perfect tube>

When a shape of a perfect cylindrical tubular body 10 with no bent, no uneven thickness, no cross-sectional distortion is measured based on the measurement principle shown in Figs. 1 to 3, as explained above, the external peripheral surface of the tubular body 10 does not change at all. Therefore, there will be no change in displacement to be detected by each of the five displacement detecting devices 30 as shown in Fig. 9(a).

[0147]

<Measurement of bent tube>

In the bent tube 101 shown in Fig. 6, since it is assumed that the internal peripheral surface is perfect circular, even if the

tubular body 10 is rotated in a state in which the pair of reference portions 20 and 20 are in contact with the internal peripheral surface of the bent tube 20 and 20, the internal peripheral surface of the tubular body in contact with the pair of reference portion 20 and 20 does not fluctuate. Accordingly, in this measurement for the bent tube 101, the tube rotates in the same manner as in the case in which the tubular body is rotated with the flanges inserted into both ends of the tubular body as shown in Fig. 6(a). Here, the misalignment of the rotation center position assumed in Fig. 5 is neglected.

[0148]

At this time, as will be apparent from Fig. 6(a), at the detecting positions 31 and 31 near both ends of the tubular body 101 facing off against the pair of reference portions, no displacement will be detected as shown in Fig. 9(a). This is apparent because of the facts that at the detecting positions 31 and 31 facing the reference portions 20 and 20 the thickness of the tubular body 101 at these positions 31 and 31 are to be detected and that in the bent tube 101 shown in Fig. 6 it is assumed that the thickness is constant.

[0149]

To the contrary, at the positions 32 other than the positions 31 and 31 facing off against the reference portions 20 and 20, as shown in the arrows under the tubular body 101 in Fig. 6(b), the external peripheral surface of the tubular body 101 is displaced in the radial direction thereof and the cycle is 360 degrees. Therefore, the deflection of the external peripheral surface as shown in Fig. 9(b) will be detected. That is, according to this method for measuring a shape of a tubular body, the deflection of the external peripheral

surface caused by the bent of the tubular body 101 can be detected.

[0150]

Furthermore, at the central position among the three central displacement detecting positions 32 of the tubular body 101, maximum deflection can be detected. The comparison of the deflection of each detecting position 32 enables to figure the fact that the defects of the tubular body 101 are caused by the bent and to figure the degree of the bent.

[0151]

The deflection of the bent tube 101 shown in Fig. 6 can also be detected by the previously mentioned conventional method (see Figs. 23 and 24) for detecting deflection of an external peripheral surface with reference to the external peripheral surface as a reference.

[0152]

<Measurement of uneven thickness tube>

In the uneven thickness tube 102 shown in Fig. 7, since it is assumed that the internal peripheral surface is perfectly circular, even if the tubular body 102 is rotated in a state in which the pair of reference portions 20 and 20 are in contact with the internal peripheral surface of the bent tube 102 and 102, the internal peripheral surface of the tubular body in contact with the pair of reference portion 20 and 20 would not fluctuate. Accordingly, in this measurement for the unevenness thickness tube 102, the tube rotates in the same manner as in the case in which the tubular body is rotated with the flanges inserted into both ends of the tubular body as shown in Fig. 7(a). Here, the misalignment of the rotation center position assumed in Fig. 5 is neglected.

[0153]

At this time, at all of the detecting positions, i.e., the detecting positions 31 and 31 at the vicinities of both ends of the tubular body 102 facing off against the pair of reference portions 20 and the detecting positions 32 other than the above detecting positions 31 and 31, as shown by the arrow under the tubular body 102 in Fig. 7(b), the external peripheral surface of the tubular body 102 is displaced in the radial direction, and the cycle is 360 degrees. Therefore, the deflection of the external peripheral surface 12 as shown in Fig. 9(b) can be detected. That is, according to this method for measuring a shape of a tubular body, deflection of the external peripheral surface due to the unevenness thickness of the tubular body 102 can be detected.

[0154]

Especially, at the detecting positions 31 and 31 facing off against the reference portions 20 and 20, the thickness of the tubular body 102 is directly detected. Therefore, it is possible to obtain the thickness distribution in the circumferential direction of the tubular body 102 from the deflection detected at the positions 31 and 31.

[0155]

Furthermore, although a tubular body generally includes defect factors such as bent or unevenness in a complex manner, according to this method for measuring a shape of a tubular body, a result reflecting these influences can be obtained by one measurement.

[0156]

Furthermore, if it is assumed that the uneven thickness is

almost the same along the entire length of the tubular body, it is possible to assume that the thickness distribution in the circumferential direction of the tubular body which will be proved from the displacement detected at the detecting positions 31 and 31 facing off against the reference portions of the tubular body 10 is the same along the entire length of the tubular body 10. In this case, although the displacement detected at the detecting positions 32 other than the detecting positions 31 and 31 facing off against the reference portions 20 includes the displacement due to the uneven thickness, it is possible to take out only the defective influences due to causes other than the unevenness by subtracting the displacement detected at the detecting positions 31 and 31. By this, regarding a tubular body having defective factors of bent and uneven thickness in a complex manner, it is possible to obtain the results affected by these influences and to evaluate the respective defective degree by separating the influences due to the defectives from the results.

[0157]

Such assumption that such uneven thickness is almost the same along the entire length of the tubular body can be made, in most case, based on the characteristics and the like of the manufacturing method of the tubular body. For example, if the tubular body is manufactured by performing a continuous extrusion and then cutting the extruded member into a predetermined length, there are many cases capable of assuming that the cross-sectional shape is almost the same along the entire length of each tubular body.

[0158]

As mentioned above, the deflection of the uneven thickness tube

102 as shown in Fig. 7 cannot be detected by a conventional method (see Figs. 23 and 24) for measuring deflection of the external peripheral surface with respect to the external peripheral surface as a reference.

[0159]

<Measurement of flat tube>

In the measurement of the flat tube 103 shown in Fig. 8, when the tubular body 103 is rotated in a state in which the pair of reference portions 20 and 20 is in contact with the internal peripheral surface of the tubular body (flat tube) 103, the tubular body (flat tube) 103 moves up and down in appearance as shown in Fig. 8(c).

[0160]

In the measuring method shown in Figs. 1 to 3, the positions facing off against the hypothetical straight line Q passing two contact points where the pair of reference portions 20 and 20 are in contact with the tubular body, i.e., the upper side of the tubular body 103 as shown in Fig. 8(c), is the position to detect the displacement. Therefore, as will be apparent from the arrow shown at the lower side of the tubular body 103, no displacement change is detected as shown in Fig. 9A. This is because the tubular body 103 has no bent and the thickness is constant. As a result, in the measuring method shown in Figs. 1 to 3, it is impossible to detect defects due to a non-circular cross-section such as a flat cross-section.

[0162]

The deflection of the flattened tubular body as shown in Fig. 8 cannot be detected even by the aforementioned conventional

deflection detecting method (Figs. 23 and 24) of the external peripheral surface with reference to the external peripheral surface.

[0162]

(Principle of a second method)

Next, as for a second method for measuring a shape of a tubular body according to the present invention, which is capable of detecting defects due to the fact that the cross-sectional shape is a non-circular shape like the flat tube 103, the principle will be explained with reference to schematic explanatory drawings.

[0163]

Fig. 10 is a front cross-sectional view showing the principle of the measuring method according to the present invention, and Fig. 11 is the side cross-sectional view thereof.

[0164]

In the aforementioned method for measuring a shape of a tubular body according to the present invention shown in Figs. 1 to 3 (hereinafter referred to as "basic method"), the five displacement detecting devices 30 are arranged at the positions facing off against the hypothetical straight line Q passing two contact portions P1 and P2 where the reference portions 20 and 20 are in contact with the internal peripheral surface of the tubular body contact from the outside of the tubular body 10. Especially, two positions 31 and 31 among the aforementioned contact positions are located at the positions facing off against the pair of reference portions 20 and 20.

[0165]

In the second method for measuring a shape of a tubular body

according to the present invention, as shown in Figs. 10 and 11, in addition to the five displacement detecting devices 30 in the aforementioned basic method, newly added five displacement detecting devices 30 are arranged.

[0166]

These newly arranged five detecting devices 30 are arranged such that these axial positions coincide with the deflection detecting positions 31 and 32 in the basic method and that the circumferential positions are positions 33 and 34 shifted by a half circumference length from the deflection detecting positions 31 and 32 in the basic method. In other words, new displacement detecting devices 30 are arranged so as to be arranged at detecting positions which are reversed phase positions (positions shifted by 180 degrees in phase) in the circumferential direction of the tubular body 10 with respect to the detecting positions 31 and 32 in the basic method.

[0167]

Like this, if the radial displacements of the external peripheral surface are detected from both sides of the tubular body 10 at each axial position, the diameter of the external peripheral surface (external circle) of the tubular body 10 at each axial position can be obtained. Concretely, the diameter displacement of the tubular body 10 in each circumferential position can be obtained by finding the differences between the displacements detected at two detecting positions of the opposite sides of the tubular body 10 at each rotational angle along the circumferential direction while rotating the tubular body 10.

[0168]

By this, at each cross-section in the axial direction of the tubular body 10 to which the detecting positions are set, it becomes possible to grasp the external peripheral shape (external shape) of the tubular body 10.

[0169]

Especially, the displacement to be detected at the detecting positions 31 and 31 facing off against the pair of reference portions 20 and 20 shows the thickness of the tubular body 10 as mentioned above. Therefore, by the detecting positions 31 and 31 and the opposed reversed phase detecting positions 33 and 33, it becomes possible to detect how the thickness and the diameter of the tubular body 10 in the cross-section change in the circumferential direction. Accordingly, in this cross-section, it is possible to grasp the cross-sectional shape.

[0170]

Furthermore, each of these detecting positions 33 and 34 correspond to the position C shown in Fig. 5. This position C is a portion receiving the least influence of the detection amount with respect to the displacement of the central position of the tubular body 10 next to the detecting position A when the central position is displaced with the internal peripheral surface of the tubular body 10 contacting the reference portions 20 and 20 during the shape measurement of the tubular body 10 (during the rotation). Therefore, even if the tubular body 10 is shifted during the shape measurement, the detected value of the displacement in the detecting positions 33 and 34 hardly receives the influence, resulting in stable shape measurement.

[0171]

<Measurement of flat tube>

In the case of performing a shape measurement of a flat tube shown in Fig. 8 by the aforementioned advanced method, as mentioned above, at the detecting positions 31 and 31 facing off against the reference portions 20 and 20 and the detecting positions 32 (the detecting positions at the lower side of the tubular body 103 in Fig. 8(c) located at the same circumferential position as the detecting positions 31 and 31, no displacement is only detected as shown in Fig. 9(a).

[0172]

To the contrary, at the detecting positions 31 and 32 and the reversed phase detecting positions 33 and 34, as shown by the arrow above the upper side of the tubular body 103 in Fig. 8(c , the external peripheral surface of the tubular body 103 is displaced in a radial direction. Since the cycle of this displacement is 180 degrees, the deflection of the external peripheral surface 12 as shown in Fig. 9(c) is detected at these detecting positions 33 and 34. That is, according to the second method for measuring a shape of a tubular body, it is also possible to detect defects due to the fact that the cross-section of the tubular body is non-circular.

[0173]

Furthermore, from the changing status of the displacement to be detected (the shape of the graph in Fig. 9(c)), it is also possible to guess the cross-sectional shape of the measured tubular body 103.

[0174]

Furthermore, although this second method can detect the defects

such as bent or uneven thickness of the tubular body in the same manner as in the first method, results reflecting the defects due to the non-circular cross-sectional shape and the influences of the defects can be obtained.

[0175]

Furthermore, by considering the typical detection pattern of each defect, it is possible to discriminate the degree, size or contents (cross-sectional shape in the case of non-circular cross-section) of each defect. This can contribute to countermeasures for solving each defect.

[0176]

In both the basic method shown in Figs. 1 to 3 and the advanced method shown in Figs. 23 and 24, it is possible to obtain the deflection corresponding to the conventional deflection of the external peripheral surface with reference to the external peripheral surface as a reference as shown in Figs. 56 and 57. In detail, from the ratio of distance between the two detecting positions 31 and 31 facing off against the reference portions 20 and 20 and another detecting positions 32 arranged at the axial central portion of the tubular body 10, the displacement that the displacement detected at two detecting positions 31 and 31 gives to another detecting positions 32 is found. Thus obtained displacement is subtracted from the actually detected displacement. Thus calculated displacement of another detecting positions 32 becomes the displacement measured with reference to the two detecting positions 31 and 31 as references.

(Manual type shape measuring apparatus)

Next, based on the aforementioned principle, a tubular shape

measuring apparatus for measuring a shape of a tubular body will be explained with reference to concrete examples.

[0178]

Hereinafter, a manual type shape measuring apparatus 4 in which a tubular body (work) 10 is rotated by a measuring operator with his/her hand will be explained with reference to Figs. 12 to 16.

[0179]

Fig. 12 is a plan cross-sectional view of the manual type shape measuring apparatus 4. Fig. 13 is a front cross-sectional view of the apparatus. Fig. 14 is a side cross-sectional view of the apparatus. Fig. 15 is a schematic perspective view of the apparatus. Fig. 16 is an explanatory view of the setting procedure of a tubular body (work) in the apparatus 4.

[0180]

This shape measuring apparatus 4 is provided with a pair of reference portions 42 and 42 which come into contact with the internal peripheral surface 11 of the tubular body 10 to become shape measuring references, pedestal portions 44 which support the tubular body 10 from the lower side thereof to stabilize the height position of the tubular body 10, a stopper 45 which comes into contact with one side end of the tubular body 10 to stabilize the axial position of the tubular body 10, deflection detecting devices 43 which come into contact with the external peripheral surface 12 of the tubular body 10 to detect the radial displacement of the external peripheral surface of the tubular body 10, and a main base 40 to which these parts are attached.

[0181]

<Pair of reference portions>

As shown in Fig. 14, etc., the pair of reference portions 42 and 42 each comes into contact with a side position of the internal peripheral surface 11 at the vicinity of each end portion of the tubular body 10 disposed horizontally or approximately horizontally, wherein the side portion corresponds to approximately the central positions in the height direction of the tubular body 10, and serves as a reference of the shape measurement.

[0182]

The pair of reference portion 42 and 42 are each constituted by a synthetic resin spherical body capable of being smoothly slid on the internal peripheral surface 11 of the tubular body 10 without scratching the internal peripheral surface 11, and attached to the reference supporting block 422 and 422 via a fixed supporting axis 421 and 421. In this embodiment, the pair of reference portions 42 and 42 do not rotate together with the tubular body 10. Therefore, the portions of the pair of reference portions 42 and 42 which is in contact with the internal peripheral surface 11 of the tubular body 10 do not change even if the tubular body 10 rotates, which causes stabilized measuring reference positions. On the other hand, it is designed such that the pair of reference portions 42 and 42 can be rotated arbitrarily when the contact portion in contact with the internal peripheral surface 11 of the tubular body 10 is abraded. Accordingly, new positions of the pair of reference portions 42 and 42 can be brought into contact with the internal peripheral surface 11 of the tubular body 10 as needed.

[0183]

Each of the fixed supporting axes 421 and 421 supporting the reference portions 42 and 42 is formed to have a cross-section smaller than that of the reference portion 42 and constituted by, for example, a metal bar having a length longer than the insertion length of the reference portion 42 inserted into the tubular body 10. This enables the setting of the tubular body (work) 10.

[0184]

Each of the reference supporting block 422 and 422 is constituted by, for example, a metal block fixed on the upper surface of the main base 40 with bolts or the like. At a portion of the main base 40 to which one of the reference supporting block 422 and 422 is mounted, an elongated hole 423 of a certain length extending along the longitudinal direction (axial direction) of the tubular body 10 is formed. By a bolt passing through this elongated hole 423, one of the reference supporting blocks 422 is fixed. Thus, the distance between the pair of reference supporting blocks 422 and 422 can be changed such that one of the reference supporting blocks 422 can be moved among a plurality of positions arranged in the axial direction of the tubular body 10 and can be fixed at any one of the positions. This enables a shape measurement in accordance with various tubular bodies 10 with different size. Furthermore, it is possible to set the contact position of the reference portion 42 at any one of various axial positions of the tubular body 10. However, the structure enabling the movement of the reference portion 42 and 42 does not aim to move the reference supporting block 422 and 422 during a shape measuring of a tubular body 10.

[0185]

Furthermore, although the bolt hole for fixing the other reference supporting block 422 is also an elongated hole 424, this elongated hole 424 is used to move the pedestal portion 44 which will be explained later, and therefore it is not necessary to move the other reference supporting block 422.

[0186]

Since the reference portions 42 and 42, the fixed supporting axes 421 and 421 and the reference supporting blocks 422 and 422 each serve as a reference for a shape measurement of a tubular body 10, it is constituted such that they have sufficient rigidity depending on the requested measurement accuracy.

[0187]

<Pedestal portion>

As shown in, for example, Figs. 13 and 14, the pedestal portion 44 supports the tubular body 10 from the lower side such that the side portion (internal peripheral side surface) of the internal peripheral surface 11 at the altitudinal middle position of the tubular body 10 is set to be approximately the same height as the pair of reference portions 42 and 42 and that the internal peripheral side surface of the tubular body 10 and the pair of reference portions 42 and 42 make contacts, to thereby stabilize the height position of the tubular body 10.

[0188]

The pedestal portion 44 include a pair of pedestal blocks 441 each fixed at the inside of the reference supporting blocks 422 and 422 with bolts or the like and contact members 442 and 442 each provided

on the upper surface of the pedestal block 441 and 441.

[0189]

The pedestal blocks 441 and 441 are movably fixed on the main base 40 with bolts passing through the elongate holes 423 and 424 formed in the main base so that the fixing position of the pedestal blocks can be changed in the same manner as the reference supporting blocks 422 and 422. Thus, in the same manner as the reference supporting blocks 422 and 422, various tubular bodies 10 with different lengths can be supported at an appropriate axial position in a state in which the height position is stabilized, thereby enabling accurate shape measurement.

[0190]

Furthermore, the pedestal block 441 is fixed to the main base 40 via one or plural height adjusting plates 443 so as to adjust the height. This enables a stable support of any tubular bodies with different cross-sectional sizes (diameters) at an appropriate height position.

[0191]

The contact member 442 is a round bar made of materials such as hard synthetic resin with smaller frictional coefficient against the external peripheral surface of the tubular body 10. Therefore, when the tubular body 10 rotates in a state in which the external peripheral surface 12 is in contact with the pedestal portions 44 and 44, the tubular body 10 can rotate smoothly without causing fluttering vibrations, enabling accurate shape measurement. As the material of the contact members 442, any material whose friction coefficient against the external peripheral surface of the tubular

body is low can be preferably used. For example, other than the aforementioned hard synthetic resin, metallic material having a flat surface can be exemplified.

[0192]

<Stopper>

As shown in, for example, Fig. 13, the stopper 45 stabilizes the axial position of the tubular body 10 by coming into contact with one of the end faces of the tubular body 10, thereby bringing the pair of reference portions 42 and 42 into contact with appropriate axial positions of the tubular body 10.

[0193]

This stopper 45 is constituted by a stopper fixing shaft 451 attached to the inside surface of the reference supporting block 422 which is not moved in the axial direction of the tubular body 10 and a stopper body 452 attached to the tip end of the stopper fixing shaft 451.

[0194]

The stopper fixing shaft 451 is formed as a metallic component extended from the inside surface of the reference supporting block 422 approximately horizontally and then bent upward.

[0195]

The stopper body 452 is formed as a short column having a circular horizontal cross-section made of synthetic resin or the like with low friction coefficient, and comes into contact with one end face of the tubular body 10 to thereby stabilize the axial position of the tubular body 10 to be rotated during the shape measurement.

[0196]

<Displacement detecting device>

The displacement detecting device 43 is brought into contact with the external peripheral surface 12 of the tubular body 10 to detect the radial displacement of the external peripheral surface. In this embodiment, contact type displacement detecting devices are arranged at three positions different in axial position of the tubular body 10. Among three displacement detecting devices 43, two side detecting devices are disposed at positions facing off against the pair of reference portions 42 and 42 and positions where the radial direction of the tubular body 10 coincides with a horizontal direction. The remaining one is disposed at the axial central position of the tubular body 10 in parallel with the aforementioned two detecting devices.

[0197]

The displacement detecting device 43 is provided with a contact roller 431 which comes into rolling contact with the external peripheral surface of the tubular body 10, a support bracket 432 to rotatably support the contact roller 431 and a movable shaft 433 with one end to which the support bracket 432 is attached. By detecting the displacement of the movable shaft 433 in the in-and-out direction, or the displacement of the contact roller (contact portion) 431, the displacement of the external peripheral surface of the tubular body 10 can be detected.

[0198]

The contact roller (contact portion) 431 is formed into a cylindrical shape, and the external surface thereof comes into line contact with the external peripheral surface 12 of the tubular body

10. Thus, the pressure acting on the external peripheral surface 10 of the tubular body 10 is dispersed, which prevents damages to the external peripheral surface 12 of the tubular body 10. Furthermore, both edges of the contact roller 431 are cut. This also prevents damages to the external peripheral surface 12 of the tubular body 10.

[0199]

Furthermore, each displacement detecting device 43 is equipped with an urging means 434 for urging the movable shaft 433 toward the tubular body 10 to thereby press the external peripheral surface 12 of the tubular body 10 on the pair of reference portions 42 and 42 via the contact roller 431. This urging means 434 is constituted by a spring or the like with one end fixed to the fixed portion 435 in the displacement detecting device 43 and the other end attached to the movable shaft 433 so as to urge the protrusion 436 formed on the movable shaft 433.

[0200]

These displacement detecting devices 43 are mounted on the detecting device mounting shaft 411 parallel to the axial direction of the tubular body 10 so as not to be rotated. Both end portions of this detecting device mounting shaft 411 rotatably penetrate a pair of main body side walls 412 and 412 fixed at opposite ends of the main base 40, and are provided with rotation operation handle 413 and 413.

[0201]

To the portions of the detecting device mounting shaft 411 disposed immediately inside the main body side walls 412 and 412,

a pair of rotation blocks 414 and 414 is attached so as not to be rotated with respect to the detecting device mounting shaft 411. Each rotation block 414 is structured such that the rotational position can be fixed by inserting a boss (not shown) inwardly protruded from the main body side wall 412 with the plunger handle 415. The rotational position to be fixed at this time is set to take a disengaging position where the contact rollers 431 of the displacement detecting device 43 are detached from the tubular body 10. As a result, it becomes possible to easily disengage the contact rollers 431 from the tubular body 10 and set the tubular body 10 to this apparatus.

[0202]

Furthermore, at the inner upper portions of the main body side walls 412, a magnet 416 is mounted to fix the rotational position of the rotation block 414 respectively. The rotational position to be fixed at this time is a position for performing a shape measurement of the tubular body 10 (displacement measuring position) in which the detecting device mounting shaft 411 is rotated with the rotation operation handle 413, and the contact roller 431 is pressed against the external peripheral surface 12 of the tubular body 10. In this state, the shape measurement of the tubular body 10 can be performed in a stable manner.

[0203]

Furthermore, each displacement detecting device 43··· is mounted on the detecting device mounting axis 411 in such a manner that the axial position can be changed and fixed at each position, so that it is possible to cope with various tubular body 10 with different lengths. Furthermore, it is possible to change the axial position

where the deflection is detected.

[0204]

<Setting of tubular body>

The setting of the tubular body (work) to the shape measuring apparatus is performed by inserting one end of the tubular body with respect to one of the reference portions (see Fig. 16(a)). At this state, the one end portion of the tubular body 10 can be deeply inserted with respect to the one reference portion 42 such that the other end portion of the tubular body 10 (Fig. 16(a)) reaches the inside of the other reference portion 42. From this state, the other end portion of the tubular body 10 is lowered so as to locate the pair of reference portions 42 and 42 inside the tubular body 10 as seen from the axial direction (see Fig. 16(b)). Thereafter, the tubular body 10 is horizontally slid so as to insert the other reference portion 42 into the other end portion of the tubular body 10 until the tubular body 10 comes into contact with the stopper body 452 to complete the setting.

[0205]

Once the tubular body 10 is set, the displacement detecting devices 43 are set to be rotatably movable by operating the plunger handle 415, and then the contact rollers 431 of the displacement detecting devices 43 are pressed against the external peripheral surface 12 of the tubular body 10 by operating the rotation operation handle 413.

[0206]

Then, while keeping the contact state in which the contact rollers 431 are in contact with the external peripheral surface 12

of the tubular body 10, an operator grasps the external peripheral surface 12 of the tubular body 10 to rotate the tubular body 10. The rotation operation of this tubular body 10 is performed by making at least one rotation or more, preferably three rotations to eliminate measurement errors.

[0207]

By detecting the radial displacement of the external peripheral surface 12 of the tubular body 10 in accordance with the rotation of the tubular body 10, the deflection of the external peripheral surface with respect to the internal peripheral surface of the tubular body 10 as a reference can be detected.

[0208]

It is preferable to continuously perform the detection of the displacement by the displacement detecting device 43 while rotating the tubular body 10. In this case, the displacement detecting device 43 can be provided with a function of storing the maximum value of the displacement from the value (reset value when reset) of the displacement at the time of initiating the rotation of the tubular body 10 while updating, a function of storing the maximum value and the minimum value of the displacement while updating, or a function of continuously storing the displacement.

[0209]

On the other hand, the detection of the displacement by the displacement detecting devices 43 can be performed at several rotation angle positions along the circumferential direction with the rotation of the tubular body 10 stopped. In this case too, if the detection of the displacement is performed at plural positions along the entire

peripheral surface, rough deflection of the displacement can be obtained.

[0210]

<Functions and results>

In the shape measuring apparatus 4 constituted as mentioned above, functions and results of the shape measuring method shown in the aforementioned Figs. 1 to 3 can be secured.

[0211]

Especially, in the shape measuring apparatus 4 shown in Figs. 12 to 16, since the displacement detecting devices 43 urge to press the tubular body 10 against the pair of reference portions 42 and 42, it is easy to maintain a stable contact state in which the pair of reference portions 42 and 42 are in contact with the internal peripheral surface 11 of the tubular body 10.

[0212]

Especially, since the tubular body 10 is supported by the pedestal portion 44 in the direction of the height and therefore the height position is stable, a measuring operator can secure an appropriate measuring environment by rotating the tubular body 10 on the pedestal portion 44 in a slidable manner while maintaining the pinched state in which the tubular body 10 is pinched by and between the pair of reference portions 42 and 42 and the displacement detecting devices 43.

[0213]

Furthermore, in this shape measuring apparatus 4, since the tubular body (work) 10 is supported from the lower side thereof by the pedestal portions 44 and 44 and there are a space formed at the

upper portion of the tubular body 10 and the side portion opposite to the displacement detecting devices 44 and 44 (back side in Fig. 15), the tubular body 10 can be easily set up or taken out form the space. Furthermore, from this space, the tubular body 10 can be easily grasped through the space and rotated. Since the rotating operation can be performed easily regardless of the manual rotation, stable rotation with less displacement can be attained, resulting in high measuring accuracy.

[0214]

(Automatic shape measuring apparatus)

Next, an automatic type shape measuring apparatus 5 in which the tubular body 10 (work) is automatically rotated by the driving force of the shape measuring device to perform the shape measuring will be explained with reference to Figs. 17 to 20.

[0215]

Fig. 17 is a front cross-sectional explanatory view showing the principle portion of the apparatus 5. Fig. 18 is a side cross-sectional view showing the principle portion of the apparatus 5. Fig. 19 is an entire perspective schematic view showing the apparatus. Fig. 20 is an enlarged perspective view showing the supporting structure of the tubular body 10.

[0216]

This shape measuring apparatus 5 is provided with a pair of reference rollers 52 and 52 which comes into contact with the internal peripheral surface 11 of the tubular body 10 to become a reference of the shape measurement, supporting rollers 54 which support the tubular body 10 from its lower side at both end portions thereof so

as to rotate the tubular body 10, light transmittance type displacement detecting devices 53 disposed so as to locate the tubular body 10 therebetween in the direction perpendicular to the axial direction of the tubular body 10, and a main body base 50.

<Pair of reference portions>

[0217]

As shown in Fig. 18, etc., each of the pair of reference rollers 52 and 52 comes into contact with the lower position of the internal peripheral surface 11 (internal lower peripheral surface) at the vicinity of the end portion of the tubular body 10 to constitute a reference for a shape measurement.

[0218]

The pair of reference portions 52 and 52 are formed into a rotatable cylindrical members in which bearings are embedded (not shown) so that the contact position can be shifted while smoothly contacting the interior peripheral surface 11 of the tubular body 10. Since the pair of reference portions 52 and 52 are formed into a rotatable cylindrical members, it comes into line-contact with the interior peripheral surface 11 of the tubular body 10, dispersing the pressure, which prevents the damage of the interior peripheral surface 11 of the tubular body 10.

[0219]

The pair of reference portions 52 are supported by reference supporting axis 521, which penetrates the device box 511 on the main base 50 so as to be disposed at both ends of the tubular body 0 in the axial direction. This structure prevents the displacement of the position of the reference roller 52 in any direction (up and down

direction and depth direction in Fig. 19) perpendicular to the axial direction of the tubular body 10.

[0220]

Furthermore, this reference supporting shaft 521 is movable in the axial direction of the tubular body 10 by the driving portion 522 provided in the device box 511. This enables the setting of the tubular body 10 to the shape measuring apparatus by moving the pair of reference rollers 52 and 52 outward in the axial direction without the necessity of moving the tubular body 10 in the axial direction.

[0221]

As shown in Fig. 4, each of the pair of reference rollers 52 and 52 comes into contact with the internal peripheral surface of the tubular body 10 at the position (supporting position) where the tubular body 10 is rotatably supported by a flange or the like which is to be inserted in use. Therefore, the shape measurement can be performed under the same conditions as the actual use.

[0222]

<Supporting roller>

The supporting rollers 54 support the tubular body 10 from its lower side at both end portions, and drive the tubular body 10. Furthermore, the supporting rollers 54 have the following functions: a function of positioning the axial position of the tubular body 10; a function of moving the tubular body 10 up and down; and a function of stabilizing the height position of the tubular body 10 by supporting it from its lower side.

[0223]

Two supporting rollers 54 are positioned at the end portions

of the tubular body 10 at the same height, and the total of four supporting rollers 54 are provided to support both end portions of the tubular body 10. The two supporting rollers 54 and 54 positioned at one of the end portions of the tubular body 10 are configured to be a pair of rollers with parallel rotational axes as shown in Fig. 18, etc.

[0224]

Each supporting rollers 54 includes a small diameter portion 541 which comes into contact with the external peripheral surface 12 of the tubular body 10 to support the tubular body 10 from its lower side and a concentric larger diameter portion 542 formed at the outside of the small diameter portion 541.

[0225]

As shown in Fig. 17, etc., the small diameter portion 541 of the supporting roller 54 is configured so as to come into contact with the tubular body 10 at a position which is outside the contact position where the reference roller 52 comes into contact with the internal peripheral surface 11 of the tubular body 10. This enables the displacement detecting device 53 to detect the displacement of the cross-section where the reference roller 52 is in contact without disturbing the detection.

[0226]

The larger diameter portion 542 of the supporting roller 54 comes into contact with the end face of the tubular body 10 to position the axial direction of the tubular body 10 to be set to the device 5. Thus, the distance between the supporting rollers 54 disposed at both ends of the tubular body 10 is set to correspond with the length

of the tubular body 10.

[0227]

The supporting rollers 54 is rotatably attached to the supporting roller support member 543 at the end of the tubular body 10, wherein the supporting roller support member 543 is slidably attached to the device box 511 such that the slide movement direction thereof is restricted only to the up-and-down direction by the slide movement direction rails 547 and 547.

[0228]

At the lower side of the supporting rollers 54, a coupling roller 544 which comes into contact with the external surface of the larger diameter portion of each supporting roller 54 is rotatably connected to the supporting roller support member 543. One of the supporting rollers 54 and 54 is driven by a driving motor 545 accommodated in the device box 511 so as to be rotatably driven. The pair of supporting rollers 54 is ratatably driven, which in turn causes a rotation of the tubular body 10.

[0229]

The supporting roller support member 543 to which the supporting rollers 54 and 54 and the coupling roller 544 are attached is slidably driven in the up-and-down direction by a lifting cylinder 546 attached to the device box 511, so that the member lifts up the tubular body 10 supported on the small diameter portion 541 of the supporting roller 54 and the tubular body 10 is brought into contact with the pair of reference portions 52 disposed inside the tubular body 10 at a certain pressing force.

[0230]

<Displacement detecting device>

The displacement detecting device 53 detects the radial displacement of the external peripheral surface 12 of the tubular body 10. In this embodiment, a total of five non-contact type detecting devices are provided at five positions different in axial position of the tubular body 10. The opposite two detecting devices among these five devices are disposed so as to detect the displacement of the cross-section of the position facing off against the reference roller 52 respectively.

[0231]

Each displacement detecting device 53 is a light transmittance type displacement detecting device disposed so as to face the tubular body 10 from the direction perpendicular to the axial direction of the tubular body 10. Thus, a pair of a light irradiating portion and a light receiving portion disposed at both sides of the tubular body 10 constitutes each displacement detecting portion 53. The light (e.g., laser beam) irradiated from the light irradiating portion but not interrupted by the tubular body 10 will be detected by the light receiving portion to thereby detect the surface position of the external peripheral surface 12 of the tubular body 10.

[0232]

The detecting region 531 and 532 of each displacement detecting device 53 has a width exceeding the diameter of the tubular body 10 as shown in Fig. 17, for example. Each displacement detecting device 53 can simultaneously detect not only the displacement of one position of the external peripheral surface of the tubular body 10 but also the displacement of a position opposite to the aforementioned one

position (a position moved from the position by a half peripheral length of the tubular body 10 in the circumferential direction thereof, a position rotated from the position by 180 degrees, or an opposite phase position).

[0233]

As a result, the displacement detecting device 53 enables a shape measurement in the same manner as in the shape measuring method shown in Figs. 10 and 11.

[0234]

The shape measuring apparatus 5 is provided with driving portion 522 for driving the pair of reference portions 52, driving motors 545 for rotatably driving the supporting rollers 54, lifting cylinders 546 for lifting the supporting rollers 54, a controller (not shown) for controlling the operation of each operating portion such as the displacement detecting device 53 for measuring a shape of a tubular body 10. The operation of each operating portion is controlled at each timing of the step of the shape measuring. The shape measuring steps can be exemplified as follows.

[0235]

In this carrying step of the tubular body 10, in a state in which each inner correcting rollers 52 is moved outward by the operation of the driving portion 522, the tubular body 10 is carried by using any carrying device or manually to be disposed on the smaller diameter portions 541 of the outer correcting rollers 54.

[0236]

Then, each inner correcting roller 52 is inserted into the tubular body 10 by the operation of the driving portion 522. In this

state, the outer correcting rollers 54 and the tubular body 10 disposed thereon are raised by the lifting cylinders 546 and 546.

[0237]

When the pair of reference portions 52 comes into contact with the internal peripheral surface 12 of the tubular body 10, the tubular body 10 is rotated via the coupling rollers 544 and the supporting rollers 54 by the driving motors 545 with the tubular body 10 pressed against the pair of reference portions 52 with a certain pressing force.

[0238]

At this time, by each displacement detecting device 53, the radial displacement of the external peripheral surface 12 at each axial directional cross-section of the tubular body 10 is detected.

[0239]

After the detection of the entire peripheral displacement by rotating the tubular body 10 one revolution or more, in the opposite steps, the rotation of the tubular body 10 is stopped and the contact state with the reference portions 52 is released by lowering the tubular body 10. The pair of reference portions 52 are moved outward again, and then the shape measured tubular body 10 is taken out.

[0240]

<Functions and effects>

The shape measurement apparatus 5 constituted as mentioned above can have the same functions and effects as those of the shape measurement method disclosed by Figs. 10 and 11.

[0241]

Furthermore, according to this automatic type shape measurement

apparatus 5, when the tubular body 10 is placed on the supporting rollers 54 and 54, the shape measurement can be performed automatically, enabling an easy employment into an automated line.

[0242]

Furthermore, the supporting rollers 54 and 54 for supporting the tubular body 10 simultaneously carry out plural functions, i.e., a function of transferring the rotational driving force to the tubular body 10, a function of positioning the axial position of the tubular body 10, a function of lifting the tubular body 10, and a function of supporting the tubular body 10 from the lower side thereof to maintain the contact state with the reference rollers 52 and 52. As a result, a structure having less number of moving portions has been attained by integrating operating portions for setting the tubular body 10 to the shape measuring position or for performing the shape measurement. Furthermore, the number of parts which come into contact with the tubular body 10 as a measuring object can be decreased. This eliminates error factors to contribute accurate shape measurement and enables high reliability of shape measurement.

[0243]

Furthermore, the supporting rollers 52 and 52 support the tubular body 10 at its end portions, enabling the cross-sections corresponding to the contact portions of the pair of reference rollers 52 and 52 to be measured. Accordingly, as mentioned above, the thickness distribution of the tubular body 10 can be obtained, and therefore, the shape of the tubular body 10 can be specified in more detail.

[0244]

Furthermore, the employment of the non-contact type displacement detecting devices 53 eliminates damages to the external peripheral surface of the tubular body 10.

[0245]

Furthermore, since this non-contact type displacement detecting device 53 is a light transmittance type displacement detecting device, the light is diffracted at the vicinity of the external peripheral surface 12 of the tubular body 10 which blocks the light to reach the light receiving portion, and therefore, appropriate detection results in which displacements of the external peripheral surface 12 due to unnecessary fine surface defects are deleted can be obtained.

[0246]

At the time of setting the tubular body 10 to the shape measuring apparatus 5, the pair of reference rollers 52 and 52 are not moved in a direction perpendicular to the axial direction of the tubular body 10. Consequently, the position to be fixed as a reference portion can be stabilized, contributing to accurate shape measurement.

[0247]

(Inspecting apparatus)

Next, a tubular body inspecting apparatus according to the present invention will be explained.

[0248]

Fig. 21 is a functional block diagram showing the structure of the inspecting apparatus 6.

[0249]

This inspecting apparatus 6 is equipped with an automatic shape

measuring apparatus 5 according to the second embodiment among the aforementioned embodiments, a deflection amount calculating portion 61 for calculating the deflection amount of the external peripheral surface 12 from the displacement data of the external peripheral surface 12 detected by the shape measuring apparatus 5, an allowable range storing portion 62 for setting and storing the allowable range of the deflection of the external peripheral surface of the tubular body 10, a comparing portion 63 for discriminating whether the deflection amount of the tubular body 10 calculated by the deflection amount calculating portion 61, and an outputting portion 64 for outputting the inspected result.

[0250]

The deflection amount calculating portion 61, the allowable range storing portion 62, the comparing portion 63 and the outputting portion 64 are comprised of software and hardware performing each function in a sequencer, etc., consisting of a computer.

[0251]

The deflection amounts treated in the deflection amount calculating portion 711, the allowable region storing portion 712 and the comparing portion 713 can be the deflection amounts at all five portions or some of them in the case where the displacements of the external peripheral surface 12 at the five portions (five cross-sections) in the axial direction of the tubular body 10 are detected by the shape measuring apparatus 5 for example.

[0252]

Furthermore, even in the case where deflection amounts of plural portions (e.g., five portions) are used, the acceptable condition

of the final inspection can be that each of all the deflection amounts fall within the predetermined allowable range or that the combination of the deflection amounts at plural portions falls within the predetermined allowable range. The example of the combination of the deflection amounts is that each of the deflection amount at the plural portions falls within the predetermined range and the total of these deflection amounts fall within the predetermined range.

[0253]

In this embodiment, the calculating means for processing the raw data of the displacement of the external peripheral surface of the tubular body 10 detected by the shape measuring apparatus 5 and calculating the index value or the like showing the shape of the tubular body 10 such as a deflection amount of the external peripheral surface is set outside the shape measuring apparatus 5. However, the shape measuring apparatus 5 can be provided with such a calculating means. Furthermore, the shape measuring apparatus 5 can have an outputting means for outputting the calculated result.

[0254]

(Manufacturing system)

Next, a tubular body manufacturing system according to the present invention will be explained.

[0255]

Fig. 22 is a functional block showing the structure of the manufacturing system 7.

[0256]

This manufacturing system 7 is provided with a tube manufacturing apparatus 71 for manufacturing a tubular body 10, the

aforementioned inspecting apparatus 6 and a judging portion 72 for judging whether the tubular body 10 is a completed item based on the inspection result of the inspecting apparatus 6.

[0257]

The tube manufacturing apparatus 721 is an apparatus for manufacturing a tube by combining the extruding and drawing of a photosensitive drum substrate. Concretely, in the case of manufacturing an aluminum alloy photosensitive drum, the apparatus is constituted as an assembly of mechanical devices for carrying a step of manufacturing extruding material by dissolving raw materials, an extruding step, a drawing step, a correcting step, a cutting step for cutting into a predetermined length, a washing step, etc.

[0258]

The tubular body 10 manufactured as mentioned above is inspected whether the shape is in a predetermined allowable range. Based on the inspection result, the judging portion 72 judges the tubular body 10 as a completed item if it falls within the predetermined allowable range.

[0259]

It is preferable that the manufacturing system 7 is provided with an automatic carrying apparatus for automatically carrying the tubular body 10 from the tube manufacturing apparatus 71 to the shape measuring apparatus 5 of the inspecting apparatus 71.

[0260]

Furthermore, it is preferable that the manufacturing system 72 is provided with a carrying apparatus for carrying the completed item judged as an accepted product by the judging portion 722 and the

possible defect product to different places.

[0261]

Furthermore, in the tubular body shape measuring apparatus 5 equipped in the inspecting apparatus 6, it is preferable to equip a feedback function for feeding the discrimination of the type or feature of the defect generated in the tubular body 10 back to the tube manufacturing apparatus 71 to prevent the generation of a defected product.

[0262]

(Another embodiments)

Although the present invention was explained with reference to each embodiment, the preferable structure regarding the ninth embodiment can be exemplified as follows.

[0263]

(1) In the above-mentioned embodiment, although the pair of reference portions are brought into contact with the positions to be supported at the time of using the tubular body, they can be brought into contact with any other positions within the internal peripheral surface of the tubular body. It is preferably the vicinity of the portion to be supported since there is a high possibility that the portion to be supported and the vicinity thereof resemble in cross-sectional shape.

[0264]

(2) In the aforementioned eleventh embodiment, although the shape measurement was performed with the axial direction of the tubular body 10 placed nearly horizontally, the measurement can be performed with the axial direction of the tubular body 10 placed nearly

vertically. This decreases the deflection of the tubular body 10 due to its own weight, enabling an accurate shape measurement of the tubular body 10.

[0265]

(3) In the aforementioned embodiment, the position facing off against the hypothetical line passing the contact portions of the pair of reference portions and the tubular body and the opposed position are used as detecting positions of the displacement. However, another position in the peripheral direction can be used as detecting positions.

[0266]

(4) In the aforementioned embodiment, although a plurality of detecting positions for a displacement of the external peripheral surface of the tubular body 10 are provided, at least one detecting position can be provided.

[0267]

(5) In the aforementioned embodiment, although a photosensitive drum substrate is exemplified as a tubular body 10 to be subjected to the shape measurement, the present invention is not limited to this, but can also be applied to a carrying roller, a developing roller, a transferring roller for use in copying machines, etc. Furthermore, any other tubular bodies can be a measuring object of the present invention.

[0268]

(6) In the aforementioned embodiment, although the positions where the pair of reference portions are brought into contact with the tubular body side portions of the internal peripheral surface

of the tubular body in the manual device and lower portions (bottom portions) of the internal peripheral surface of the tubular body in the automatic device. However, it is not limited to this, but can be upper portions (ceiling portions) of the internal peripheral surface of the tubular body.

[0267]

(7) In the aforementioned embodiment, as a displacement detecting device, in the manual type shape measuring device 4, a contact type detecting device which comes into contact with the external peripheral surface of the tubular body 10 is exemplified, and in the automatic type shape measuring device 5, a non-contact type detecting device (transparent type optical sensor) which comes into contact with the external peripheral surface of the tubular body 10a is exemplified. However, a displacement detecting device is not limited to these devices so long as a radial displacement of the external peripheral surface of the tubular body 10 can be obtained. As another displacement detecting devices0, it is possible to employ any detecting device based on various measuring principles, such as a reflection optical sensor capable of detecting the displacement in a non-contact state, an all-purpose image processing CCD camera or line camera capable of detecting the displacement in a non-contact state and applicable to any material, a current-type displacement sensor capable of detecting the displacement in a non-contact state and high in accuracy, high in processing speed, strong in environment and cheap in cost, a capacitance-type displacement sensor capable of detecting the displacement in a non-contact state and high in accuracy, an air-type (differential pressure type) displacement

sensor capable of detecting the displacement in a non-contact state, or an ultrasonic type displacement sensor capable of performing a long distance measurement.

[0270]

(Effects of the invention)

As mentioned above, the method for measuring a shape of a tubular body according to the present invention comprises: making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body; rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body at at least one position outside the tubular element, the at least one position being fixed relative to the circumferential direction of the tubular element. Since the deflection of the external peripheral surface to be measured reflects the influence of uneven thickness, it is possible to prevent the accumulation of device differences and/or a request of excessive quality which may occur in the case of separately measuring the thickness of the tubular body. Furthermore, since the deflection of the external peripheral surface to be measured reflects the influence of uneven thickness, the time required to conduct the measurement can be shortened. Furthermore, since the external peripheral surface is measured by bringing the reference portion into contact with the internal

peripheral surface, the structure can be simplified, decreasing the accumulation of measuring errors as small as possible, resulting in a high accuracy shape measuring. Furthermore, since it is enough to bring the reference portion into contact with the internal peripheral surface, this method can be preferably applied to a method of measuring a shape of a tubular body having a smaller diameter. It is enough that the position of the reference portion is fixed when the tubular body is rotated to detect the displacement of the external peripheral surface of the tubular body. For example, the position can be moved when the tubular body is set to an apparatus for measuring the shape. Furthermore, it is enough that the position of the reference portion is fixed. The posture can be changed, e.g., rotated.

[0271]

In such a measuring method, in cases where the pair of reference portions is brought into contact with supporting positions at the time of using the tubular body, since the shape measurement can be performed by making the reference portion for rotation operations at the actual use of the tubular body as a reference, it becomes possible to perform measurement in a situation near the actual case.

[0272]

In cases where the pair of reference portions is brought into approximately point-contact with the internal peripheral surface of the tubular body respectively, it becomes possible to perform a shape measurement clearly specifying the measurement reference.

[00273]

In cases where the pair of reference portions is arranged in a horizontal direction, the tubular body takes a posture with the

axial direction approximately horizontal. However, in cases where the tubular body is used in this posture, it becomes possible to obtain measured results similar to those in the use.

[0274]

In cases where the pair of reference portions can be arranged in a vertical direction, the deflection of the axially central portion of the tubular body due to its gravity can be prevented, which makes it possible to measure its original shape.

[0275]

In cases where detecting positions of the displacement include at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body, the position facing off against the hypothetic straight line from outside the tubular body is a position where radial displacement of the external peripheral surface of the tubular body barely receives the influence of the shift of the rotational central position of the tubular body. Therefore, if the position includes such position, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement.

[0276]

A method for measuring a shape of a tubular body according to the present invention comprises: making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body; rorating the tubular body such that contact portions where the tubular body and the pair of

reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and detecting radial displacement of the external peripheral surface of the tubular body at at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body. With this method for measuring a shape of a tubular body, deflection of the external peripheral surface with respect to the internal peripheral surface can be measured. That is, the deflection of the external peripheral surface to be measured reflects the influence of the uneven thickness of the tubular body. The position facing off against the hypothetic straight line from outside the tubular body is a position where radial displacement of the external peripheral surface of the tubular body barely receives the influence of the shift of the rotational central position of the tubular body. Therefore, if the position includes such position, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement.

[0277]

In cases where the detecting positions of the displacement include a position other than a position facing off against the pair of reference portions from an outside of the tubular body, deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body can be measured.

[0278]

In cases where the detecting positions of the displacement include plural positions located outside the tubular body, the deflection of the external peripheral surface at the plural positions located outside the tubular body can be measured, and therefore, by combining these it becomes possible to grasp the shape of the tubular body more concretely.

[0279]

Furthermore, in cases where the detecting positions of the displacement include plural positions different in the axial direction of the tubular body, the deflection of the external peripheral surface at the plural positions different in the axial direction of the tubular body can be measured, and therefore, by combining these it becomes possible to grasp the shape of the tubular body more concretely.

[0280]

Furthermore, in cases where the detecting positions of the displacement include plural positions which are the same in axial directional position of the tubular body but different in peripheral directional position thereof, by combining the displacements detected at a plurality of positions, it is possible to grasp the cross-sectional shape of the tubular body at the axial position more concretely.

[0281]

Furthermore, in cases where the detecting positions of the displacement include two positions which are the same in axial directional position of the tubular body but different in peripheral directional position by a half peripheral length of the tubular body,

by combining the displacements detected at two positions, it is possible to obtain the diameter of the tubular body passing two positions. Thus, the cross-sectional shape of the tubular body at the axial position more concretely.

[0282]

Furthermore, in cases where the detecting positions of the displacement include a position outside the tubular body facing off against at least one of the pair of reference portions, it is possible to detect the thickness of the tubular body at the portion where the reference portion is in contact with. By combining this thickness with the detected results at another detecting positions, the cross-sectional shape of the tubular body at the axial position more concretely. For example, it is also possible to calculate inspected results in accordance with a conventional inspection method in which displacement of the external peripheral surface of another position with respect to the external peripheral surface of the vicinity of the end portion of the tubular body as a reference is measured.

[0283]

A method for measuring a shape of a tubular body according to the present invention comprises: making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body; rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and detecting radial displacement of the external peripheral surface

of the tubular body at a position outside the tubular body facing off against at least one of the pair of reference portions and at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body. With this method for measuring a shape of a tubular body, it is possible to detect the thickness of the tubular body at the portion where the reference portion is in contact with from the displacement of the external peripheral surface at the position facing off against the reference portion. Furthermore, from the displacement of the external peripheral surface at the position facing off against a hypothetical linear line, deflection of the external peripheral surface with reference to the interior peripheral surface of the tubular body, i.e., deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body, can be measured. Especially, the position facing off against the hypothetical linear line from the outside of the tubular body is a position where the radial displacement of the external peripheral surface is barely affected by the influence of the shift of the rotational center of the tubular body. Therefore, by taking such a position as a detecting position of the displacement, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement. By combining the detected thickness of the tubular body and the deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body, t becomes possible to grasp the shape of the

tubular body more concretely. For example, it is also possible to calculate inspected results in accordance with a conventional inspection method in which displacement of the external peripheral surface of another position with respect to the external peripheral surface of the vicinity of the end portion of the tubular body as a reference is measured.

[0284]

A method for measuring a shape of a tubular body according to the present invention comprises: making a pair of reference portions come into contact with internal peripheral surfaces of vicinities of both end portions of the tubular body; rorating the tubular body such that contact portions where the tubular body and the pair of reference portions come in contact with each other shift on the internal peripheral surface in a circumferential direction of the tubular body with positions of the pair of reference portions fixed; and detecting radial displacement of the external peripheral surface of the tubular body at a position outside the tubular body facing off against at least one of the pair of reference portions, a position different from the position in peripheral directional position by a half peripheral length of the tubular body, and at least one position facing off against a hypothetic straight line passing two contact portions where the internal peripheral surface of the tubular body and the pair of reference portions is in contact from an outside of the tubular body. With this method for measuring a shape of a tubular body, it is possible to detect the thickness of the tubular body at the portion where the reference portion is in contact with from the displacement of the external peripheral surface at the position facing

off against the reference portion. Furthermore, from the displacement of the external peripheral surface at the position facing off against a hypothetical linear line and the deflection of the external peripheral surface facing off against the reference portion, the diameter passing through these two positions can be can be measured. Furthermore, from the displacement of the external peripheral surface at the position facing off against a hypothetical linear line, the deflection of the external peripheral surface with reference to the interior peripheral surface of the tubular body, i.e., the deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body can be measured. Especially, the position facing off against the hypothetical linear line from the outside of the tubular body is a position where the radial displacement of the external peripheral surface is barely affected by the influence of the shift of the rotational center of the tubular body. Therefore, by taking such a position as a detecting position of the displacement, even if the rotational central position of the tubular body is shifted, stable measurement can be performed, resulting in high reliable measurement. By combining the detected thickness of the tubular body and the deflection of the external peripheral surface reflecting the influence of the uneven thickness of the tubular body, t becomes possible to grasp the shape of the tubular body more concretely. For example, it is also possible to calculate inspected results in accordance with a conventional inspection method in which displacement of the external peripheral surface of another position with respect to the external peripheral surface of the vicinity of the end portion of the tubular body as

a reference is measured.

[0285]

Furthermore, in cases where the number of the rotation of the tubular body is one or more, it is possible to detect the shape along the entire periphery of the tubular body.

[0286]

In cases where the detection of the displacement is performed continuously during the entire period or a part of the period for rotating the tubular body, it is also possible to detect a partial shape change in the peripheral direction of the tubular body.

[0287]

In cases where the detection of the displacement is performed intermittently during the period for rotating the tubular body, it is possible to easily detect the displacement of the external peripheral surface of the tubular body.

[0288]

In cases where the rotation of the tubular body is intermittently stopped and the detection of the displacement is performed when the rotation of the tubular body is stopped, it is possible to stably detect the displacement of the external peripheral surface of the tubular body.

[0289]

In cases where the detection of the displacement is performed by using a detecting device which comes into contact with the external peripheral surface of the tubular body, it is possible to assuredly detect the displacement of the external peripheral surface of the tubular body.

[0290]

In cases where the detection of the displacement is performed by using a detecting device which does not come into contact with the external peripheral surface of the tubular body, it is possible to detect the displacement of the external peripheral surface of the tubular body without harming the external peripheral surface of the tubular body.

[0291]

In cases where the detection of the displacement is performed by irradiating light against the tubular body from the outside thereof and detecting the light passed over the tubular body, it is possible to easily and accurately detect the displacement of the external peripheral surface of the tubular body.

[0292]

A method for inspecting a tubular body according to the present invention comprise the steps of measuring a shape of the tubular body in accordance with the method of measuring a tubular body as recited in any one of the aforementioned Items, and inspecting based on the measured result whether the shape of the tubular body falls within a predetermined allowable range. With the method for inspecting a tubular body, it is possible to discriminate whether the shape of the tubular body falls within a predetermined allowable range.

[0293]

A method for manufacturing a tubular body according to the present invention comprises the steps of manufacturing a tubular body, inspecting a shape of the tubular body by the inspection method of a tubular body as recited in the aforementioned Item; and

discriminating that the tubular body is a completed product if the inspection result shows that the shape of the tubular body falls within the predetermined allowable range. With this method for manufacturing a tubular body, it is possible to provide a tubular body having sufficient shape accuracy without excessively increasing the quality.

[0294]

An apparatus for measuring a shape of a tubular body according to the present invention comprises: a pair of expandable clamps to be brought into contact with an internal peripheral surface of the tubular body at both end portions of the tubular body; and at least one displacement detecting device provided outside the tubular body for detecting a radial displacement of the external peripheral surface of the tubular body, wherein the displacement detecting device detects the displacement in accordance with the rotation of the tubular body when the tubular body is rotated together with the reference portion about a rotational axis around the central axis of the pair of reference portions. With this method for measuring a shape of a tubular body, it is possible to measure the deflection of the external peripheral surface of the tubular body. That is, the deflection of the external peripheral surface reflects the influence of the uneven thickness of the tubular body in cases where the interior peripheral surface of the tubular body to be measured is supported. Therefore, it is possible to conduct a measurement similar to the using state of the tubular body. Furthermore, since the deflection of the external peripheral surface reflects the influence of the uneven thickness of the tubular body, it is possible to prevent accumulation

of variation of measuring devices and an excessive quality request which are required when a thickness of the tubular body is measured separately. Furthermore, since the deflection of the external peripheral surface reflects the influence of the uneven thickness of the tubular body, it is possible to shorten the measuring time. Furthermore, since the measurement of the external peripheral surface is performed simply by bringing the reference portion into contact with the interior peripheral surface, the structure can be simplified, reducing the accumulation of the measuring errors as low as possible, which in turn can obtain high accuracy of shape measurement. Furthermore, since it is enough to bring the reference portion into contact with the internal peripheral surface, this method can be preferably applied to a method of measuring a shape of a tubular body having a smaller diameter.

[0295]

An apparatus for inspecting a shape of a tubular body according to the present invention comprise the apparatus for measuring a shape of a tubular body as recited in the Item, and a comparative means for inspecting whether the shape of the tubular body falls within a predetermined allowable range based on the displacement detected by the displacement detecting device. With the apparatus for inspecting a tubular body, it is possible to discriminate whether the shape of the tubular body falls within a predetermined allowable range.

[0296]

A system for manufacturing a tubular body according to the present invention comprises a tube manufacturing apparatus for

manufacturing a tubular body, an inspection apparatus for a tubular body as recited in the aforementioned Item, an acceptance/rejection discriminating means for discriminating that the tubular body is a completed product if the inspection result by the inspection apparatus shows that the shape of the tubular body falls within the predetermined allowable range. With the system for manufacturing a tubular body, it is possible to provide a tubular body having sufficient shape accuracy without causing excessive quality.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is a front cross-sectional view showing the principle of the method for measuring a shape of a tubular body according to the present invention.

[Fig. 2]

Fig. 2 is a side cross-sectional view showing the same.

[Fig. 3]

Fig. 3 is a perspective view showing the principle of the method for measuring a shape of a tubular body according to the present invention.

[Fig. 4]

Fig. 4 is an explanatory perspective view showing the usage state of a tubular body (work) to be measured.

[Fig. 5]

Fig. 5 is an explanatory view showing the detecting position of the displacement in the method for measuring a shape of a tubular body according to the present invention.

[Fig. 6]

Fig. 6(a) is a perspective view showing a bent tube as a defect tubular body, and Fig. 6(b) is a cross-sectional view thereof.

[Fig. 7]

Fig. 7(a) is a perspective view showing an uneven thickness tube as a defect tubular body, and Fig. 7(b) is a cross-sectional view thereof.

[Fig. 8]

Fig. 8(a) is a perspective view showing a flattened tube as a defect tubular body, and Fig. 8(b) is a cross-sectional view thereof.

[Fig. 9]

Fig. 9 is a graph showing examples of results of displacement of the external peripheral surface of the tubular body (work) to be measured detected while rotating the tubular body (work).

[Fig. 10]

Fig. 10 is a front cross-sectional view showing the second principle of the method for measuring a shape of a tubular body according to the present invention.

[Fig. 11]

Fig. 11 is a side cross-sectional view showing the same.

[Fig. 12]

Fig. 12 is a flat cross-sectional view showing an embodiment embodying a shape measuring apparatus according to the present invention as a manual device.

[Fig. 13]

Fig. 13 is a front cross-sectional view thereof.

[Fig. 14]

Fig. 14 is a side cross-sectional view thereof.

[Fig. 15]

Fig. 15 is a schematic perspective view hereof.

[Fig. 16]

Fig. 16 is an explanatory view of the setting steps of the tubular body (work) according to the present invention.

[Fig. 17]

Fig. 17 is a flat cross-sectional view showing an embodiment embodying a shape measuring apparatus according to the present invention as an automatic device.

[Fig. 18]

Fig. 18 is a side cross-sectional view thereof.

[Fig. 19]

Fig. 19 is an entire schematic perspective view hereof.

[Fig. 20]

Fig. 20 is an enlarge perspective view showing the supporting structure of the tubular body.

[Fig. 21]

Fig. 21 is a functional block showing the structure of an inspection device of a tubular body according to the present invention.

[Fig. 22]

Fig. 22 is a functional block showing the structure of a tube manufacturing system according to the present invention.

[Fig. 23]

Fig. 23 is an explanatory view showing the principle of a conventional method for measuring a shape of a tubular body.

[Fig. 24]

Fig. 24 is an explanatory view showing the principle of a conventional method for measuring a shape of a tubular body.

[Description of the reference numeral]

10 tubular body (work)

11 internal peripheral surface

12 external peripheral surface

20, 42, 52 reference portion

30, 43, 53 displacement detecting portion

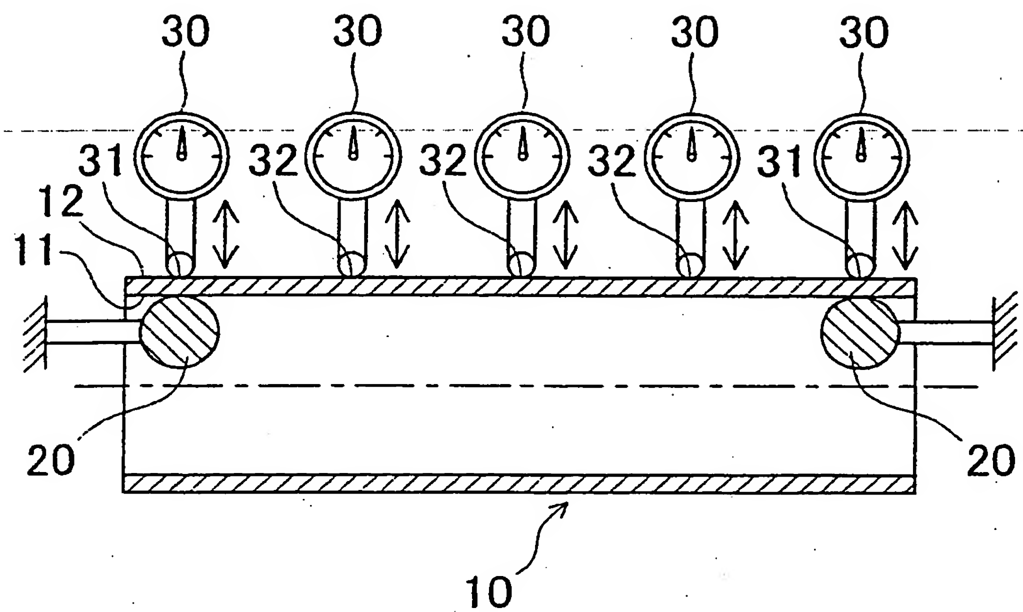
31, 32, 33, 34 detecting position of the displacement

P1, P2 contact portion

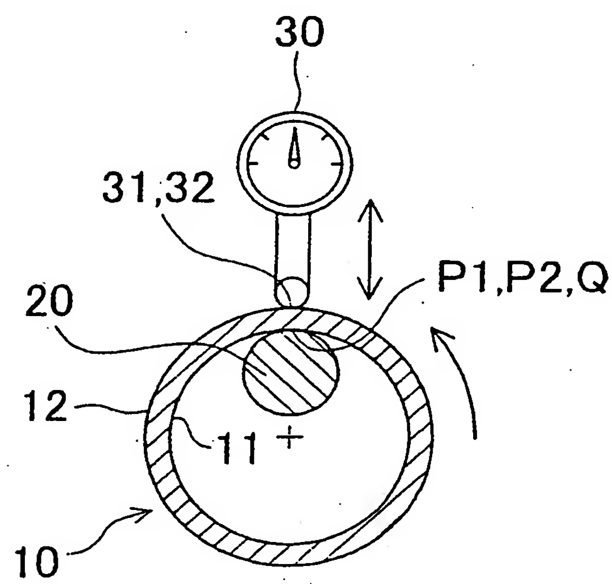
Q hypothetical linear line

[Name of Document] Drawings
【書類名】　図面

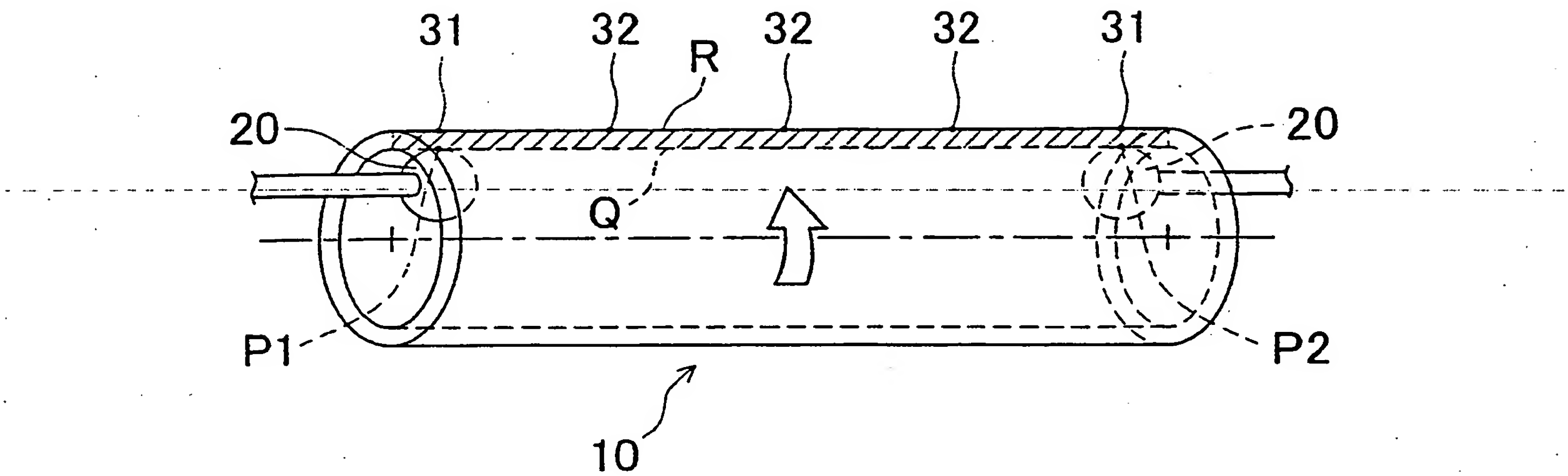
【図1】 [Fig. 1]



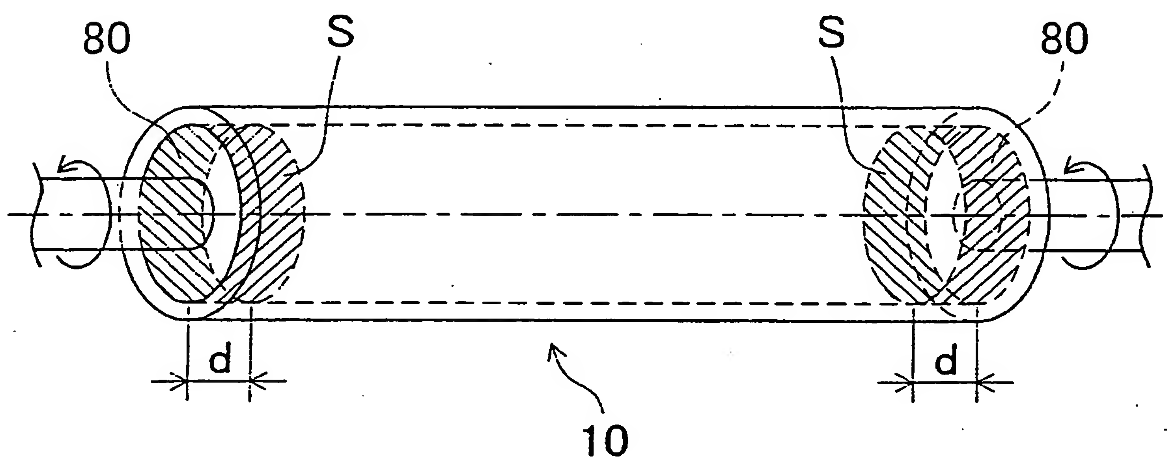
【図2】 [Fig. 2]



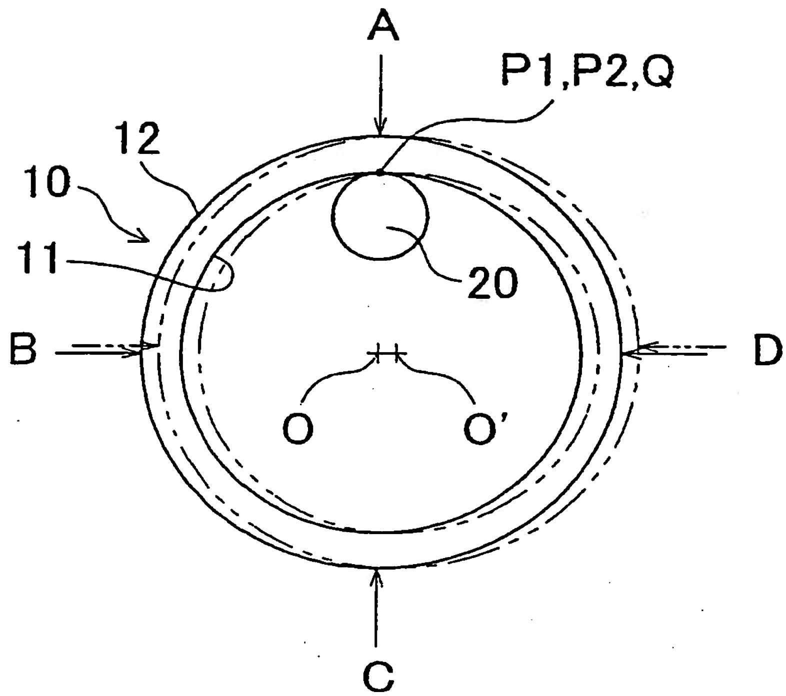
【図3】 [Fig. 3]



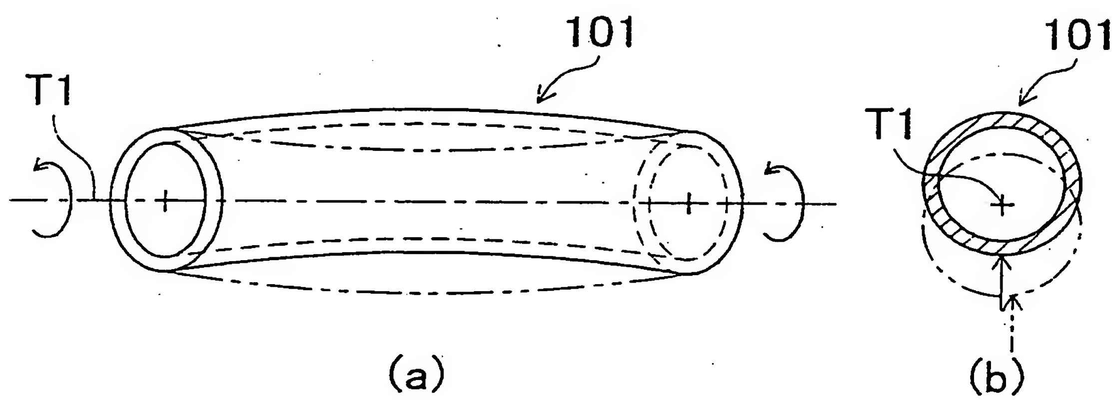
【図4】 [Fig. 4]



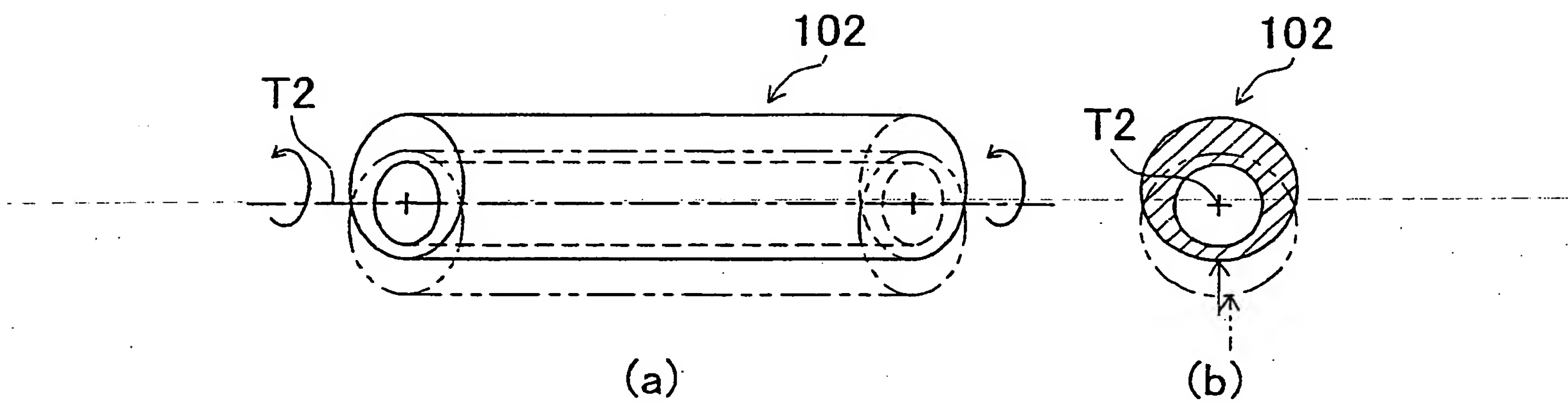
【図５】 [Fig. 5]



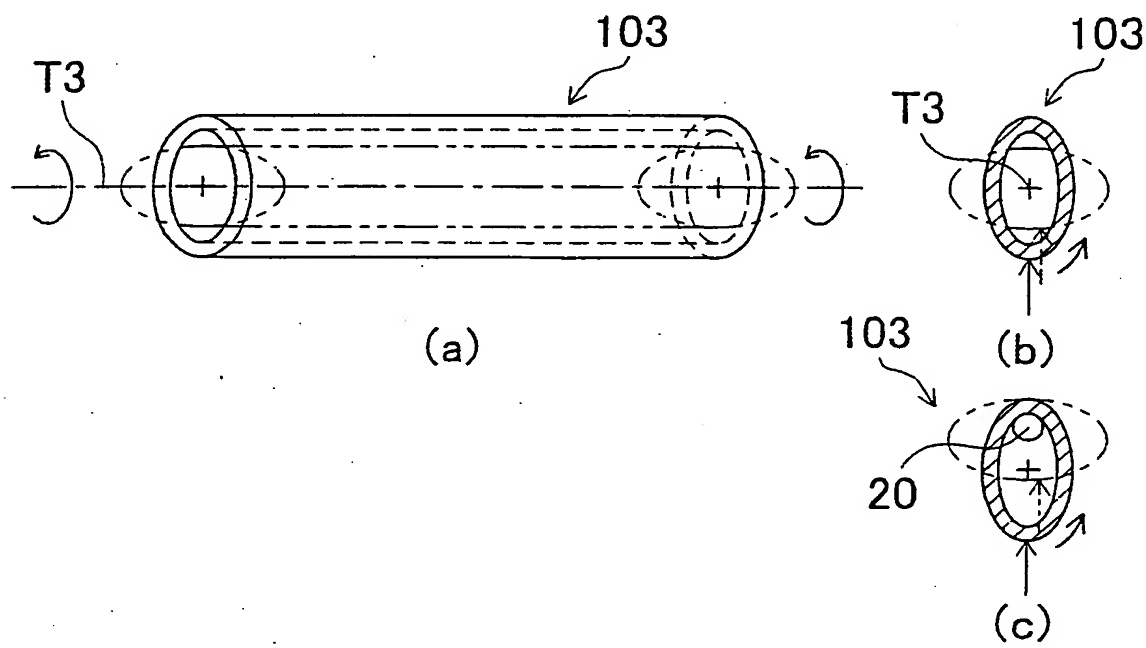
【図６】 [Fig. 6]



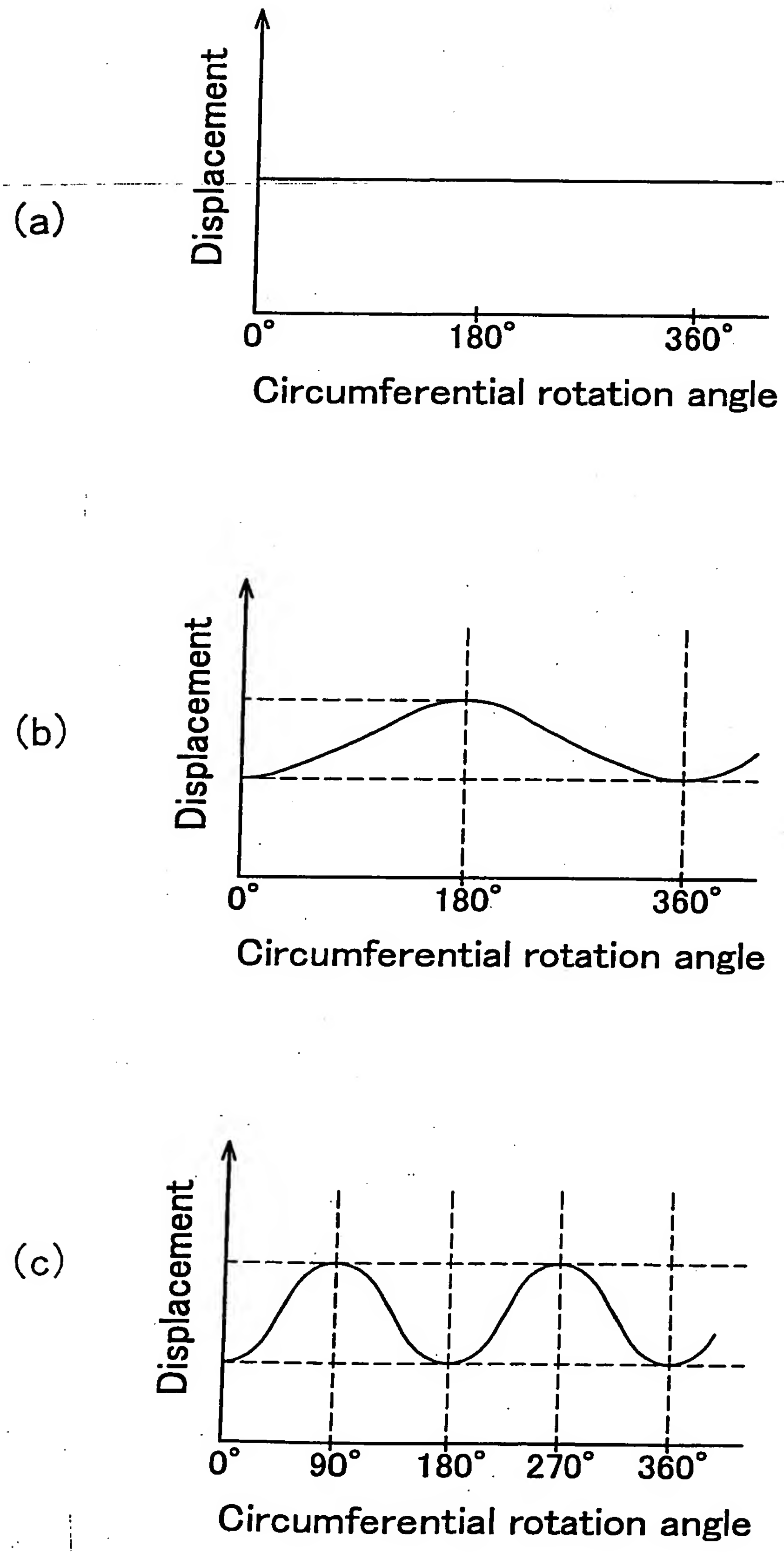
【図7】 [Fig. 7]



【図8】 [Fig. 8]



【図9】 [Fig. 9]


(a)
Displacement
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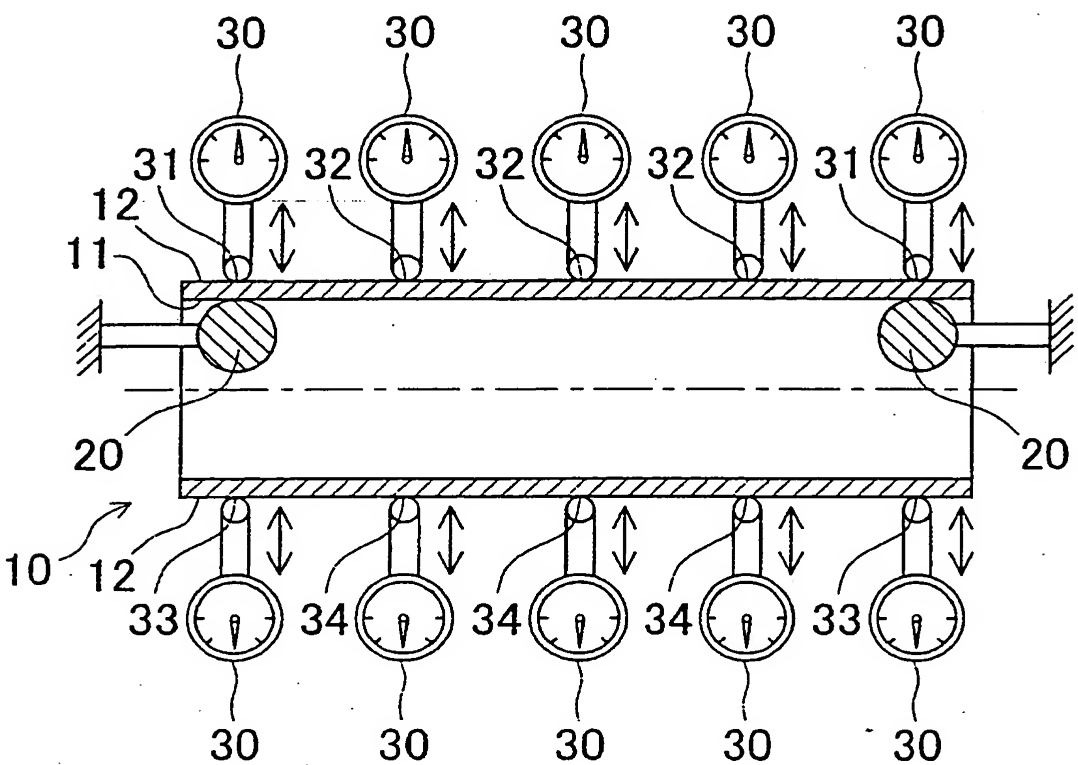
180°
360°
Circumferential rotation angle
(b)
Displacement
0°
180°
360°
Circumferential rotation angle
(c)
Displacement
0°
90°
180°
270°
360°
Circumferential rotation angle

【図10】 [Fig. 10]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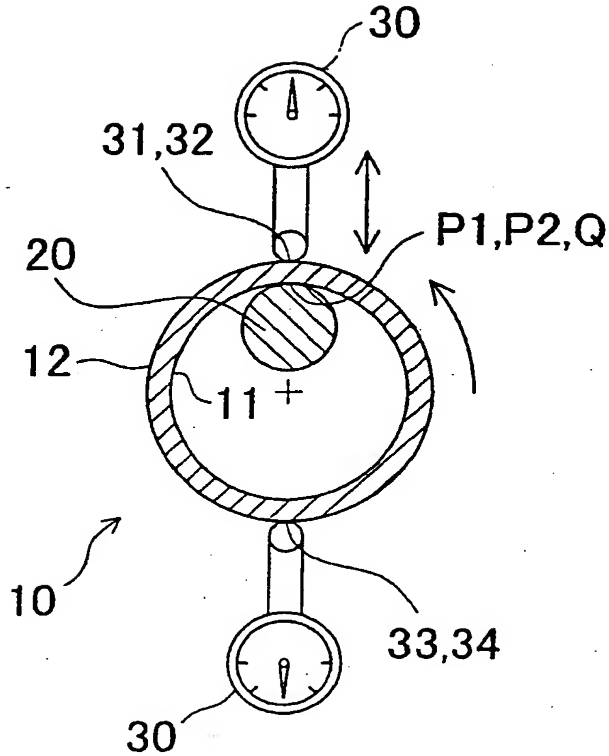
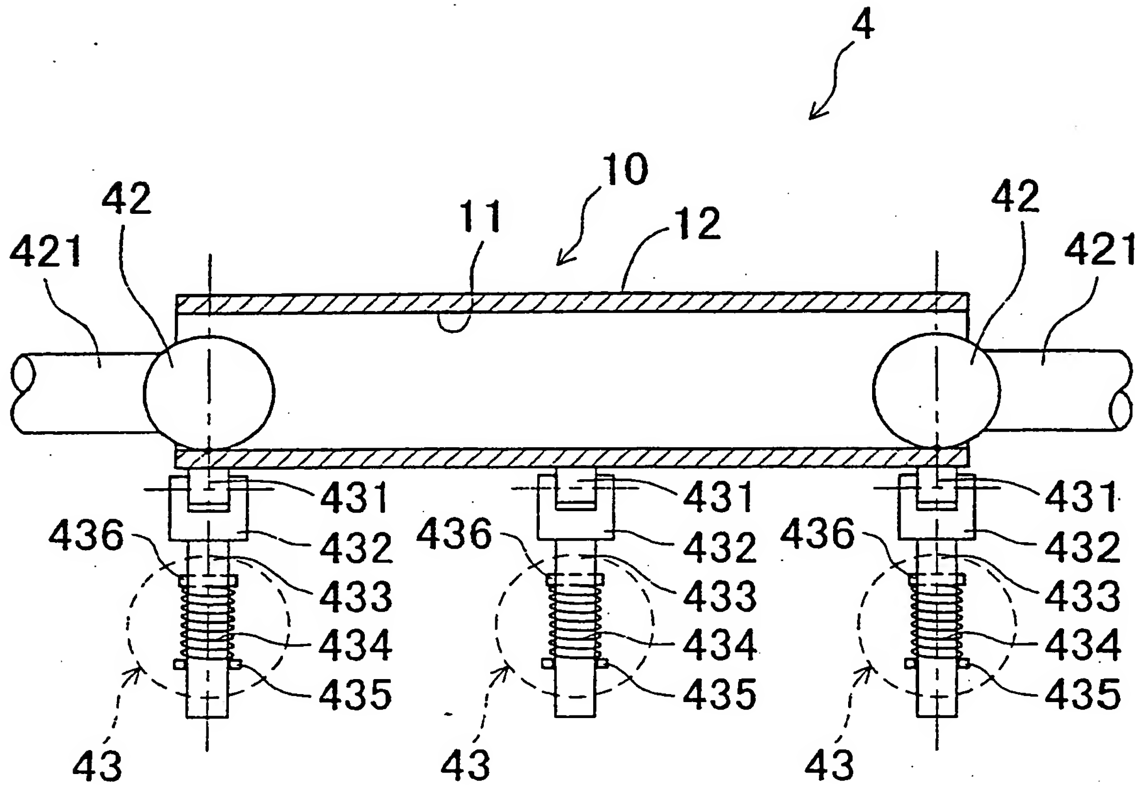
【図１１】 [Fig. 11]



【図12】 [Fig. 12]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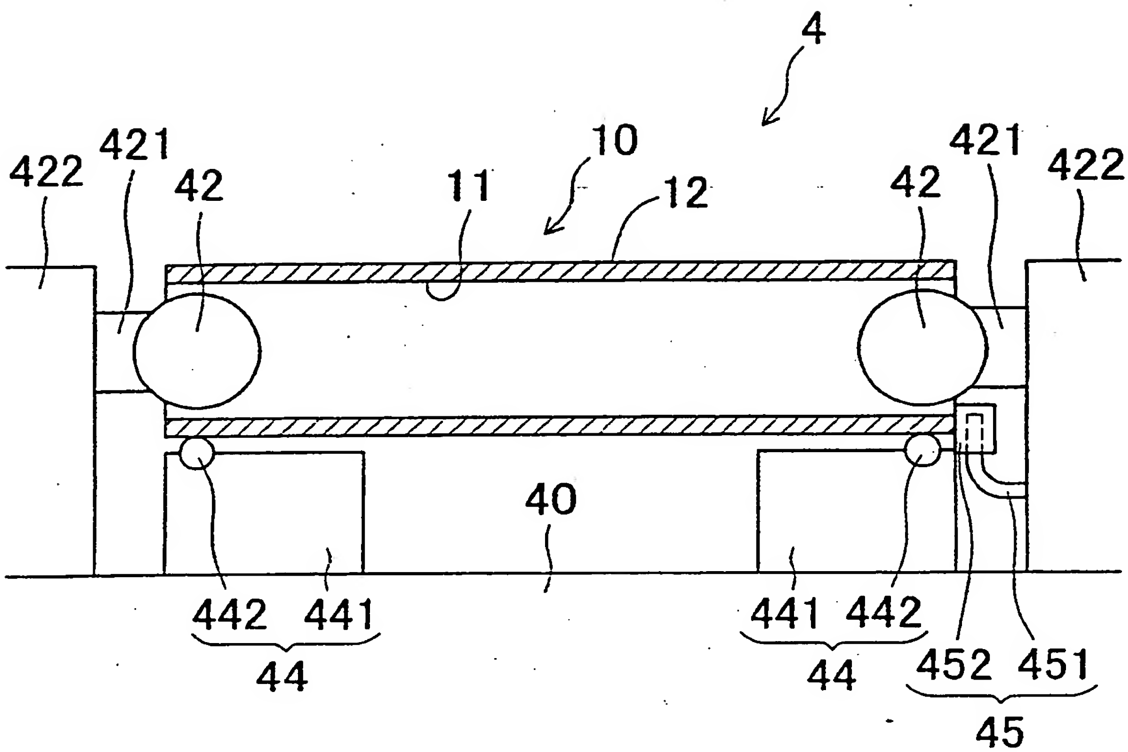
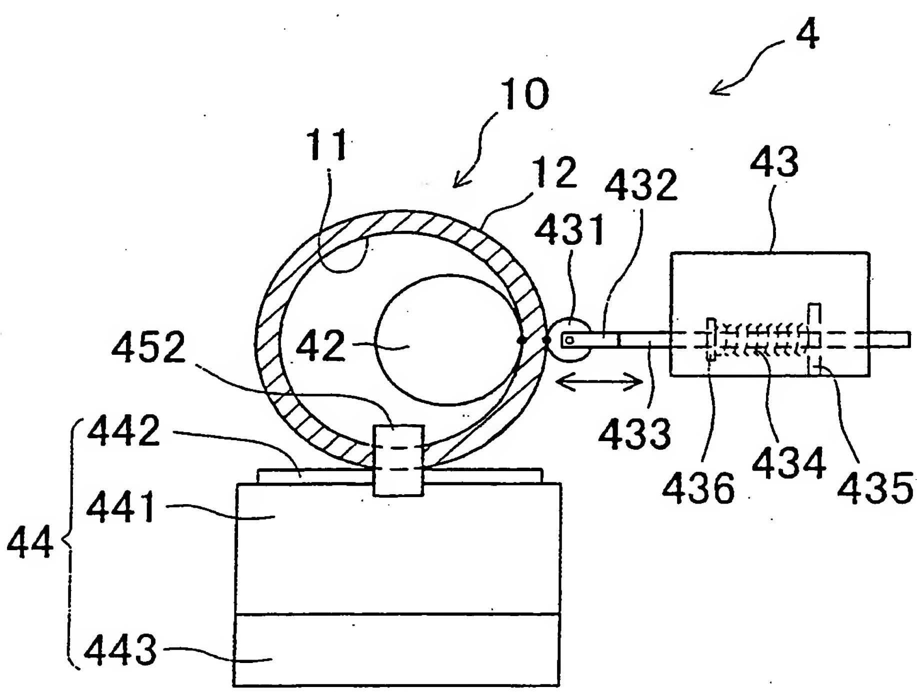
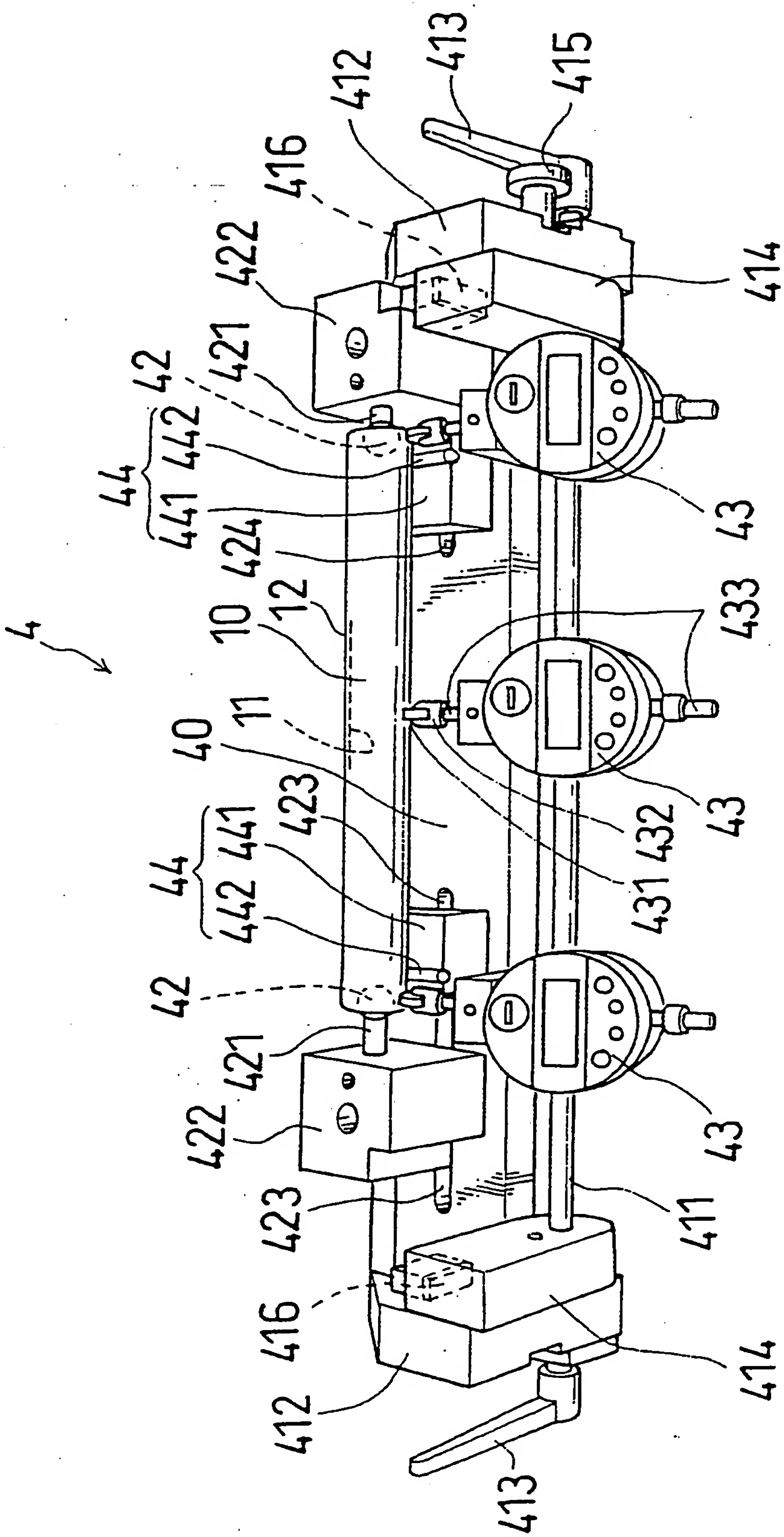
【図１３】 [Fig. 13]



【図１４】 [Fig. 14]



【図15】 [Fig. 15]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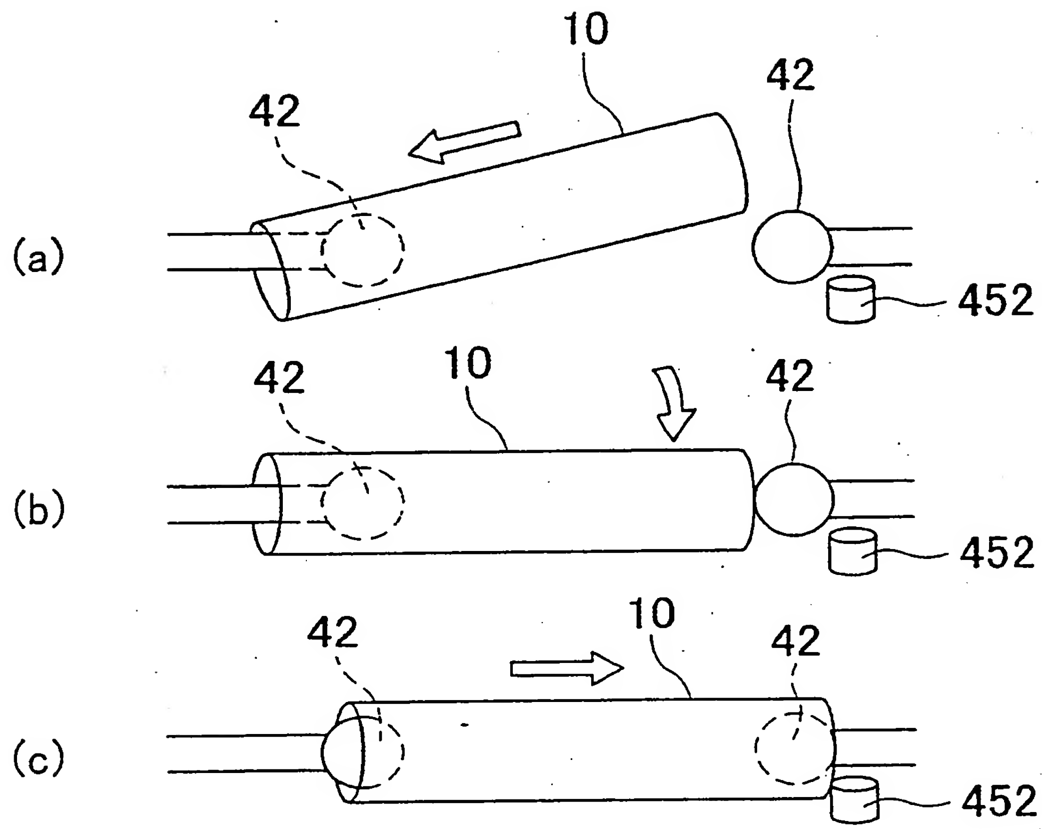
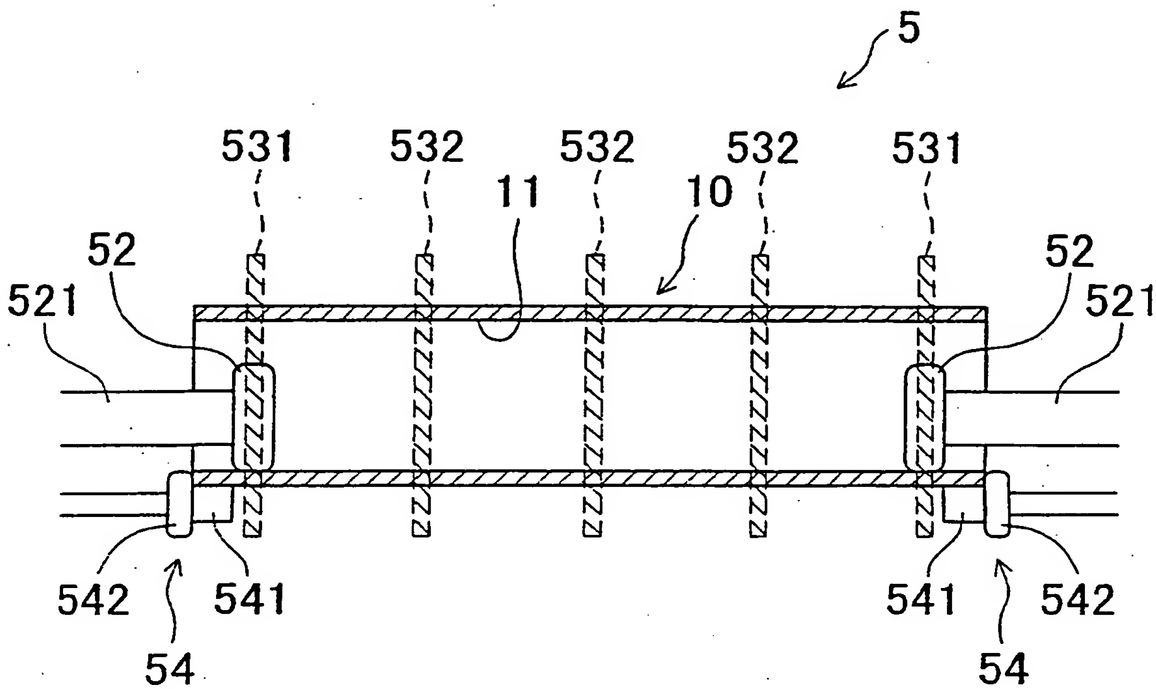
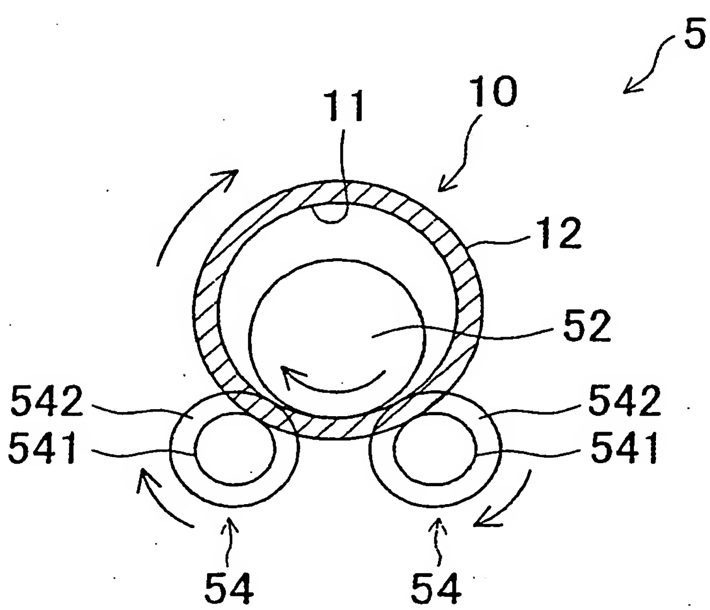
【図16】 [Fig. 16]



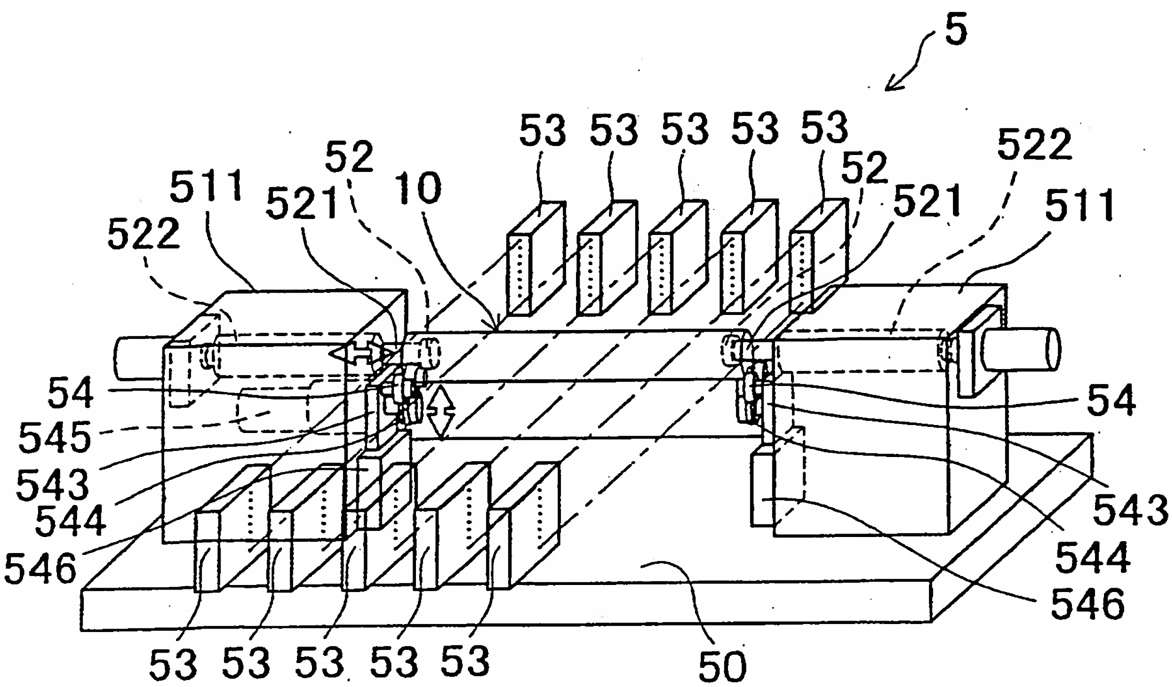
【図17】 [Fig. 17]



【図18】 [Fig. 18]



【図19】 [Fig. 19]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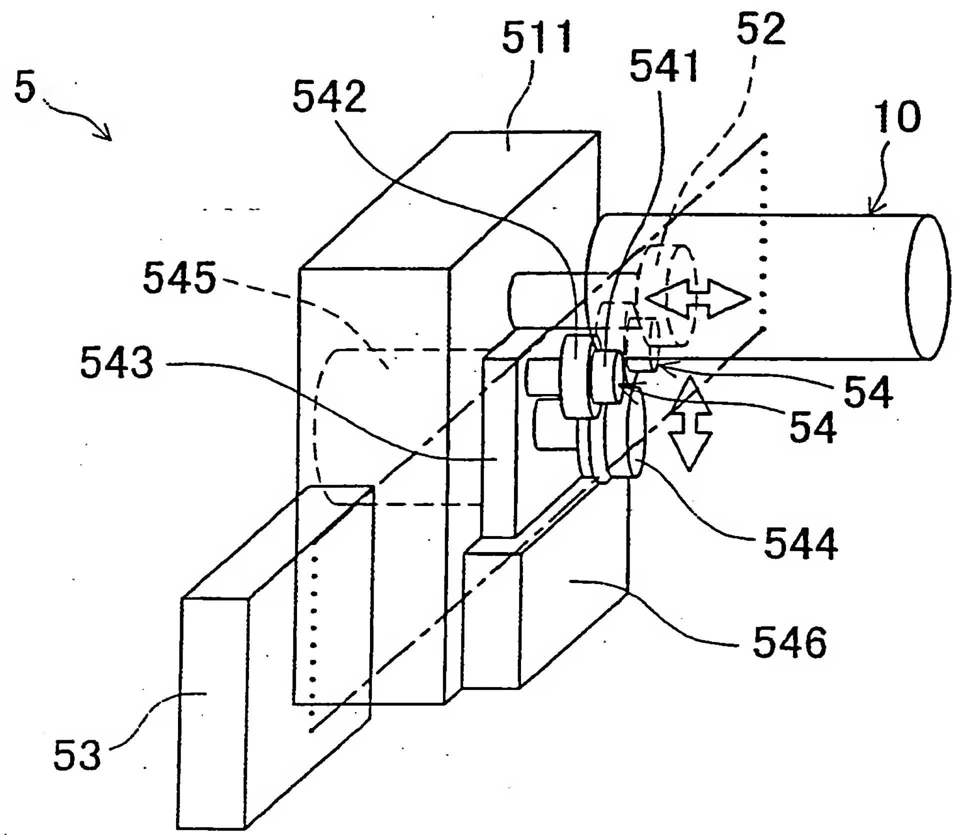
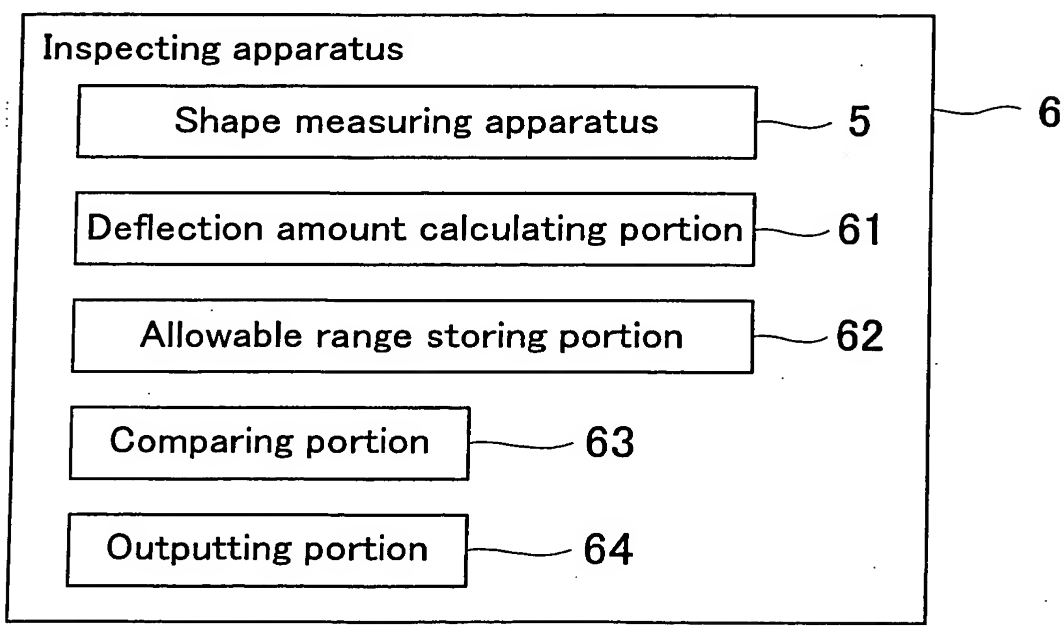
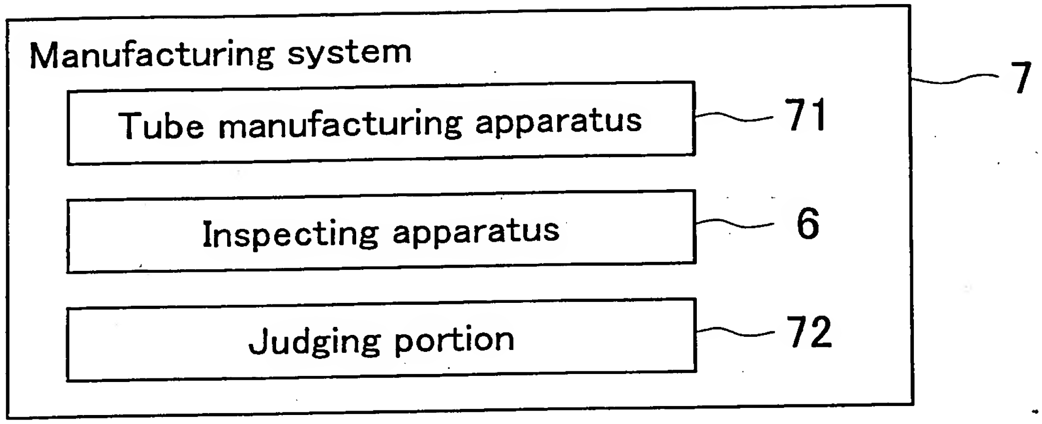
【図20】 [Fig. 20]



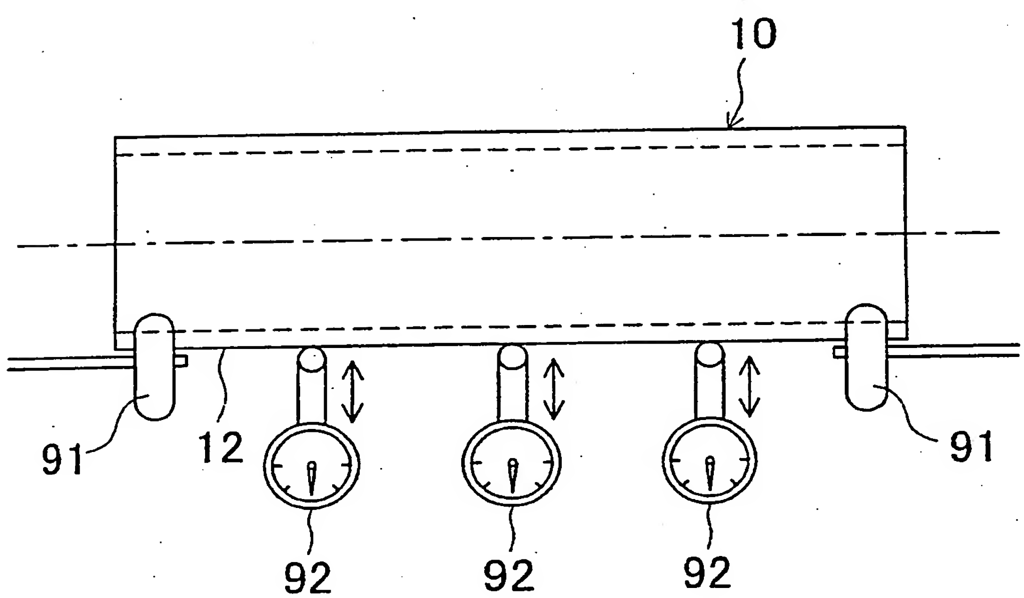
【図21】 [Fig. 21]



【図22】 [Fig. 22]



【図23】 [Fig. 23]



【図24】 [Fig. 24]